PSYCHOLOGY

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GENERAL INTRODUCTION

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PREFACE

There is very general agreement as to the main topics which must be treated in a text-book on psychology. There is, however, no accepted method of approaching these topics, and, as a result, questions of emphasis and proportion are always matters of individual judgment. It is, accordingly, not out of place for one to attempt in his preface to anticipate the criticism of those who take up the book, by offering a general statement of the principles which have guided him in his particular form of treatment. This book aims to develop a functional view of mental life. Indeed, I am quite unable to accept the contentions, or sympathize with the views of the defenders of a structural or purely analytical psychology. In the second place, I have aimed to adopt the genetic method of treatment. It may be well to remark that the term genetic is used here in its broad sense to cover all that relates to general evolution or individual development. In the third place, I have attempted to give to the physiological conditions of mental life a more conspicuous place than has been given by recent writers of general text-books on psychology. In doing this I have aimed to so coördinate the material as to escape the criticism of producing a loose mixture of physiology and introspective description. In the fourth place, I have aimed to make as clear as possible the significance of ideation as a unique and final stage of evolution. The continuity running through the evolution of the sensory and motor functions in all grades of animal life is not, I believe, the most significant fact for psychology. The clear recognition of this continuity which the student reaches through studies of sensation and habit, and even perception, is the

firmest possible foundation on which to base an intelligent estimate of the significance of human ideational processes. The clear comprehension of the dominant importance of ideational processes in man's life is at once the chief outcome of our study and the complete justification for a science of psychology, distinct from all of the other special disciplines which deal with life and its variations. The purpose of this book may, therefore, be stated in terms which mark as sharp a contrast as possible with much that has been said and written of late regarding the advantages of a biological point of view in the study of consciousness. This work is intended to develop a point of view which shall include all that is given in the biological doctrine of adaptation, while at the same time it passes beyond the biological doctrine to a more elaborate principle of indirect ideational adaptation.

In the preparation of this book I am under double obligation to A. C. Armstrong. As my first teacher in psychology, he has by his broad sympathies and critical insight influenced all of my work. Furthermore, he has given me the benefit of his judgment in regard to all parts of this book while it was in preparation. Two others I may mention as teachers to whom I am largely indebted. The direct influence of Wilhelm Wundt will be seen at many points in this book. As the leader in the great advances in modern psychology, especially in the adoption of experimental methods, and as the most systematic writer in this field, he has left his impression on all who have worked in the Leipzig laboratory to an extent which makes such a book as this in a very large sense of the word an expression of his teaching. Finally, I am indebted to William James. I have received instruction from him only through his writings, but take this opportunity of acknowledging his unquestioned primacy in American psychological thought and the influence of his genius in turning the attention of all students to the functional explanations of mental life which it is one of the aims of this book to diffuse.

My colleagues, Dr. R. P. Angier and Dr. E. H.

Cameron, read the manuscript and gave me many valuable suggestions which have been incorporated into the text. Mr. C. H. Smith assisted me in the preparation of the figures.

C. H. J.

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CHAPTER I

INTRODUCTION

Psychology as a science.

PSYCHOLOGY is the science of consciousness. Any one who seeks to understand the various forms of consciousness which appear either in his own experience or in the mental lives of others is in his degree a psychologist. On the other hand, one who does not study the conditions and nature of mental processes is not a psychologist, even though he has many conscious experiences. Animals furnish an extreme illustration of the latter type, for though they see and hear, they never make a study of their visual and auditory processes. Children are also striking illustrations, for while they become more and more clearly conscious of the things which are about them, they seldom if ever stop to inquire how it is that they are gaining knowledge. Even the experiences of adult life take place for the most part without being made subjects of study. One reads a book or looks at a picture and gains information without asking himself how the process of knowledge arises, or what is the nature of the information which he has acquired.

Exceptional experiences the first motives for scientific study.

The motives which have led men to make a scientific study of their conscious processes are numerous and varied in character. Perhaps the most common of all these motives is to be found in the exceptional and baffling experiences which every one has from time to time. One thinks he hears a voice, but finds on examination that nobody spoke. One tries to grasp an object which he sees, but finds that for his sense of touch the thing is not what it seems to be for his

sense of vision. Such experiences as these require some explanation, and even the most superficial observer is likely to become interested, at least for the moment, in their scientific interpretation. Popular psychology seldom gets beyond this examination of striking and unique experiences; consequently the notion has gained wide currency that psychology is devoted entirely to the investigation of occult phenomena.

Individual differences as cardinal motives for psychological study.

Interest in exceptional experiences is hardly a sufficient motive, however, to lead to long-continued systematic study. It is to be doubted whether psychology would ever have developed into a serious science unless other more fundamental motives had arisen to turn the attention of men to the examination and explanation of their conscious processes. The more fundamental motives began to appear as far back as the time of the Greeks. These early thinkers found themselves in bitter intellectual controversies. Given the same facts and the same earnest effort to use these facts in the establishment of truth, the Greeks found that two individuals were often led to opposite conclusions. This made it clear that the processes by which men arrive at conclusions must themselves be studied. To this task the Greek philosophers set themselves with enthusiasm, though with inadequate methods, and out of their efforts arose the earliest schools of serious psychological investigation.

Physical science demonstrated the indirect character of knowledge.

Another fundamental motive appeared in the early part of the modern period as a direct outgrowth of the discovery that there is a disparity between the facts discovered by physical science and the direct testimony of consciousness. Thus Sir Isaac Newton discovered that he could break up white light into all the colors of the rainbow. Conscious experience of white light is, on the contrary, absolutely simple and unanalyzable. Even among the students of physical science there had never been any hesitation up to the time of Newton in assuming that external white light is just as simple as human consciousness of whiteness. The ancients had a definite explanation of vision which

shows that they explicitly believed in the simplicity of external white light. Light was for them a series of particles emanating from the object and entering the eye. When they saw white, they believed that the experience was due to white particles in the eye, and that these white particles came from a white body. All was uninterrupted likeness from consciousness to the physical object. Such an explanation of white light as that offered by the ancients was rendered utterly untenable by Newton's discovery. When further investigations led physicists to define light and other forms of physical energy as modes of vibration, the breach between conscious experience and external reality became so wide that men felt compelled to study conscious experience as well as physical facts. It is noteworthy that the period during which Newton and his successors were making their discoveries in physics was a period of the profoundest interest in psychological problems.

Biological motives for the study of consciousness.

As reënforcements to the impetus given to psychological study by discoveries in physics, new motives for such study arose with the development of physiology, and especially with the establishment of the biological doctrine of evolution. Every highly developed function of an animal is recognized in biology as having its relation to the struggle for existence. If an animal can run well, we find this ability serviceable in saving the animal from enemies, or in helping it to procure food. If an animal has keen vision, we find that the animal depends on this sense in the essential activities of life. With such facts clearly before us, we cannot escape the question, What part does consciousness play in the economy of life? From the lower forms of animal life up to the highest, we find a steady increase in the scope of intelligence. In the highest animals we find mental evolution carried so far that intelligence is very often of more significance than any other single function or even group of functions. If we turn from the study of animal evolution to the study of man's place in the world, the question of the place of consciousness in evolution

takes on new importance. The digestive functions of a man differ very little from those of the higher animals; the muscles and bones and organs of circulation in man are very much like those of his near relatives in the animal kingdom. In matters of intelligence, on the other hand, man has never been in any doubt of the wide difference between himself and even the highest of the animals. Man lives in a world of ideas from which animals are excluded by their lack of intelligence; he prepares for even his physical needs by foresight and by the intelligent use of tools. Man has, in short, through his conscious activities attained to a mode of struggle for existence which is unique. We cannot understand and explain human life and human institutions without studying the facts and laws of consciousness; without raising the question of the relation of consciousness to all of man's other attributes.

Psychology late among the sciences.

What has been said of the motives which have gradually led to the development of a science of psychology shows why the growth of this science has been slow. It is a general fact that consciousness of one's self is a very late product of mental development. The race turned first, as does the child, to the outer world and devoted its earliest attention to the conquest of the physical forces which surround it and condition its existence. The physical sciences came to maturity long before the sciences of man. When men thought about themselves in the early days, it was very seldom that they took anything like a scientific attitude; they thought rather of their destiny and origin in broad, speculative, or even purely mythological terms. Little by little as the outer world yielded to scientific investigation, man began to see in himself a subject for study. At first he took up somewhat hesitatingly his own body, then he began to realize that his social relations exhibit certain regularities which can be formulated into the general principles of economic and social science. Finally, he was forced, as we have seen, through motives which grew up very gradually, to examine his own mental constitution. Psychology is, accordingly, one of the latest of the sciences.

Introspection.

When men first became conscious of the psychological problem, that is, the problem of explaining their own mental lives, they were very much impressed by the fact that the method of observing conscious processes is different from the method of observing the facts of the physical world. Every one is shut up so far as his direct observation of conscious experiences is concerned to his own mental life. The earlier psychologists emphasized this fact and insisted that the only true method of psychological observation is the method of self-observation, or introspection as it is called. Thus, when one has an emotion, others may see its external expressions, but only the man himself can observe the conscious state which constitutes the emotion. In observing this conscious state, he introspects. It is very clear that the early psychologists were right when they pointed out the unique importance of introspection. It has come to be equally clear, however, that the early psychologists imposed an unwarranted limitation upon their science when they contended that introspection is the only possible method of collecting psychological facts. The most notable progress in the psychology of the last few decades has been the elaboration of the methods of the science. It cannot be asserted that introspection has been superseded, but it can be said that it has been very greatly elaborated by the development of additional methods and by the comparison of the results of introspection with a large body of considerations which could never have come into psychology so long as it was held that introspection is the only method of gathering psychological facts.

Experimental methods.

One of the first and most important among the elaborations of psychological method consisted in the development of experimentation in dealing with the facts of conscious life. In the early period of psychology, men observed their conscious processes only as these processes chanced to arise in the ordinary course of life. It was a new departure when, about the middle of the last century, psychologists deliber-

ately set about producing certain experiences under well-defined conditions with a view to making their observations more systematic and complete. Of the advantages of such deliberate observation, there can be no question. Take a simple example. If an observer finds himself turning away from a group of objects, he may realize that he has chanced upon an opportunity of asking himself how fully he remembers the group. Later, he may repeat the question and note how much he has forgotten in the interval. He will hardly fail to find out by this sort of self-observation much that will help him in describing his processes of memory. Suppose, however, that he wishes to find out with definiteness the law which memory exhibits in its decay, or suppose that he wishes some final decision as to the best way of examining groups of objects in order that he may carry away a complete and permanent memory of them. He will find it advantageous for this more complete study to arrange the objects with a definite view to the questions which he wishes to answer. He will observe the objects during a fixed period, and after a known interval will submit his memory to a definite test. This illustration is sufficient to show that there are advantages in the definite arrangement of the conditions of observations, which is the first step in experimentation. If, now, the psychologist adds certain aids in the way of apparatus which will make it easy to record the time intervals and to present the matter to be memorized in absolutely uniform fashion, it will be recognized at once that the more fully developed and precise method of investigation leads to a degree of accuracy in ascertaining the facts, which is otherwise quite impossible. The experimental method also makes it possible for observers remote from one another to collect their observations under the same conditions, so that they can compare their results and generalize the information which they have gathered.

There has been much discussion as to the exact place of experiment in psychology, some holding that it is the only true scientific method, others holding

that it is very limited in its application. Those who are most devoted to experimental methods have sometimes gone so far as to assert that experimental psychology is a separate discipline. Those who criticise the method point out that the profounder emotions, such as intense sorrow, and the higher forms of abstract thought, such as are involved in a scientific discovery, cannot be produced and modified at will. Both extreme positions are to be avoided. Carefully prearranged observation under controlled conditions, wherever this is possible, is the true ideal of scientific psychology. Where experiment is not possible, other forms of observation must and should be employed.

The limitations of experimentation in psychology.

With the introduction of experimental methods has come a second notable enlargement of the scope of psychology. Psychology no longer devotes itself merely to direct introspective observations; a variety of related indirect observations are freely utilized in the explanation of mental life. The indirect methods of collecting information regarding conscious processes have certain advantages over introspection, because introspection disturbs, to some extent, the mental process which is being examined. Furthermore, many of the forms of conscious experience and all of the conditions of experience are beyond the range of introspection. Thus the mental processes of abnormal and undeveloped individuals cannot be contributed through introspection to the science of psychology, and yet the facts of abnormal and immature mental activity have been productively utilized in recent investigations as material on which to base scientific generalizations. Furthermore, the facts of nervous activity which are from their nature inaccessible through introspection have been drawn into psychology, and nothing has done more to broaden our understanding of the meaning and value of consciousness. Human consciousness is so obviously related to the processes in the organs of sense and in the central nervous system, that it requires little or no argument to convince even the plain man that a study of the senses and of the brain contributes to

Psychology utilizes facts not ascertained through introspection.

the explanation of conscious experiences. If we add to this general statement regarding the relation of bodily processes to human experience, the further statement which will be fully supported in our later discussions, that all through the animal kingdom there is an evident parallelism between the complexity of the nervous system of any given species of animals and the degree of intelligence exhibited by that species, we have ample justification for introducing into psychology a discussion of the nervous system and its development.

Behavior as psychological material.

Another type of indirect or non-introspective investigation which has of late been cultivated with very great advantage to psychology deals with the forms of human and animal behavior. Here, as in the examination of the nervous activities, it is possible to discover certain stages of development and to relate these to the well-recognized general fact that there are progressive stages of intelligence in the animal kingdom.

Indirect methods supplement introspection.

If these and other modes of indirect study of mental life are judiciously added to introspective observations of one's own conscious processes, psychology loses nothing of its directness, and it gains much in breadth.

Processes most open to introspection often complex rather than fundamental.

A further advantage which is secured by recognizing that introspection is not the only possible method of collecting psychological facts, is that the combination of indirect and direct examination throws the experiences most directly open to introspection into a truer perspective. The student who depends solely on introspection will give the largest share of his attention to that which is in the foreground, usually to some complex mental process which passes slowly across the stage of consciousness. He will often give undue weight to some single experience because it is so clear, adopting this clear experience as typical, and depending upon it for the explanation of many of the less obvious facts of mental life. For example, when one hears a word and stops to consider deliberately the conscious process by which

he interprets the word, he is very likely to experience a series of memory images which follow upon the word and give it meaning. Thus, let the reader ask himself what he thinks of when he sees the word "house." The more carefully he searches in his consciousness, the more he becomes aware of trains of memory images. Many psychologists having made this introspective observation set it down as a general fact of all mental life that the process of recognition always consists in the revival of trains of memory images. If the skeptical observer ventures to say that he does not find in his ordinary recognition of words such attendant trains of memory images, he is reproved for incomplete introspection. When we come to the problem of recognition of words in our later discussions, this question will be taken up in detail, and it will be shown that what is needed is not a formula borrowed from the more elaborate, easily introspected case, in which recognition is slow and long drawn out. What is needed is a formula derived from the general study of mental development as conditioned by nervous structures and by the relation of impression to expression. Without attempting to anticipate fully the later treatment of the matter, enough has been said to serve the ends of the present discussion. Introspections made on elaborate mental processes should not be applied to simple and less easily introspected processes without the greatest caution. The fallacy of excessive devotion to formulas derived through introspection has been one of the stumbling-blocks in the way of psychological science. Introspective observations should constantly be checked and corrected by other introspections and also by external evidences which throw indirect light on the nature of mental organization. If this is done such conscious processes as recognition will not be defined as made up of trains of images.

There is another danger closely related to that which has just been described. The student of mental life may become so absorbed in the observation and description of his mental processes that he will over-

Observation must always be supplemented by generalization.

look the fact that observation is merely the beginning of science. We cannot arrive at scientific generalizations without supplementing any single observation, however carefully that observation is made, by comparison and interpretation. To enforce this statement, attention may first be called to certain analogies from physical science, and second to an illustration from human experience which shows that observation must be supplemented by interpretation in order to reveal the true character of the phenomena. The analogies which show the limitations of physical observation are as follows: We observe that the surface of the earth about us is apparently flat. We observe, also, a variety of other facts which are incompatible with the notion that the earth is flat. We note all these observations and compare them, and finally accept as our general scientific conclusion the statement that the earth is spherical, and not flat, as it seems to ordinary observation. Again, we do not hesitate to accept the dictum of science that the earth is moving at a tremendous rate, although we do not observe the movement directly. These illustrations go to show that scientific conclusions are broader in scope than single observations, and frequently so different from the single observations as to constitute essentially new facts.

Difficulty of accepting inferences in psychology.

When we leave physical science where we have learned easily to accept the results of inference, and turn to psychology, we do well to remember that earlier generations less trained in the methods of science found it difficult, indeed quite impossible, to substitute inferences about the shape and motion of the earth for the facts of sense experience. We should therefore be prepared by the consideration of these analogies to recognize the necessity of comparison and interpretation in our psychology and to overcome our own hesitation in accepting psychological inferences as substitutes for introspective observations.

A simple mental experience which offers an excellent opportunity for the application of the principle of inference is as follows: Let an observer close one

Observations on the blind spot.

eye and look with the open eye at the printed page before him. He will undoubtedly observe what seems to be an uninterrupted series of impressions coming to him from all parts of the page. This is, however, quite as incomplete a description of the facts as is the description of the earth's surface based upon direct observation. To demonstrate this, let the observer close or cover the left eye and look steadily with the right eye at the small cross in Fig. 1.

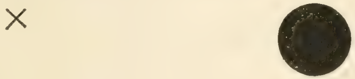

Fig. 1. For demonstration of the blind spot. (*See* text.)

Now let him move the book backward and forward from seven to eight inches in front of his face until the black circle disappears. He will thus discover that a certain part of the page is not yielding an uninterrupted series of impressions. Indeed, what he seems to see in this part of the field of vision is not a direct impression at all; it is some kind of substitute for direct impression, and is different in character from that which his first observation of the field of vision suggested. The explanation of all the facts here involved cannot be obtained through introspective observation, and clearly when the final explanation is given, it must deny the simple statement which the observer would naturally make on the basis of his first glance at the page. This illustration should prepare the student to find in the science of psychology many statements about the nature of his conscious processes, which he cannot expect to verify by a simple process of observation. Observation is indispensable, but the scientific understanding of consciousness requires an elaborate interpretation of all the facts which can be obtained.

A few remarks concerning the scope of psychology may be added to the discussion of motives and methods presented in the foregoing paragraphs. The field of

Various forms of psychological study.

psychological study is as wide as the scope of consciousness. Indeed, in so far as psychology finds it necessary to study the conditions of consciousness, the scope of this science reaches beyond the boundaries of conscious life itself and includes, as has been indicated in an earlier paragraph, all the physiological and physical facts which contribute in any way to the experience of any conscious being. So wide a discipline naturally divides into a number of special branches. There is a psychology of animal consciousness. There is a psychology of the child's consciousness, especially cultivated by those who wish to ascertain the laws of mental development which underlie education. There is a psychology of abnormal human minds known by the special name of psychiatry. There is a psychology of the products of human minds when they act in social groups as in the development of language, customs, and institutions. This is called social psychology or folk psychology. Certain other lines of subdivision are sometimes drawn. Thus, experimental psychology has sometimes been marked off from other forms of investigation. Physiological psychology has also been treated as a separate science. Finally, it is not uncommon to meet such titles as the psychology of art, or of literature; the psychology of religion, of the crowd; and so on through a long list of highly differentiated specialties.

Reasons for subdivision.

Some confusion has resulted because of the tendency of psychology to break up into so many minor disciplines. The confusion disappears, however, as soon as one recognizes that, in methods and subject-matter, all the special psychologies are merely parts of the general science. The explanation of the subdivisions is partly historical. As new interests or new methods have asserted themselves, the traditions of the earlier stage of psychology have often resisted the innovation to such a degree that a new discipline was for a time necessary to accomplish the development of the science. In addition to these historical reasons, the breadth of human interests in the study of experi-

ence is so great that the mastery of any single phase of mental life involves a concentration somewhat more pronounced than that which is required in many sections of the physical sciences.

Purposes of a general course in psychology.

The special departments of psychology cannot all be fully treated in a general course, such as that which is to be given in the following chapters. Much can be touched upon only by way of illustration. The general treatment must confine itself to the establishment of broad principles applicable in greater or less degree to all of the special fields. With this necessity of general exposition in mind, the statement with which this introductory chapter began may be amplified as follows. The legitimate function of a course in general psychology is to consider the typical processes of mental life with reference to their internal constitution and also with reference to their external conditions; to examine these processes with the aid of experiments and observations from both the introspective and impersonal points of view; and, finally, to relate consciousness to the other phases of life and to external reality in such a way as to furnish the basis for an adequate understanding, not only of individual consciousness, but also of the experience of all conscious beings.

Definitions of general terms.

In this statement and throughout the chapter, the terms consciousness, mental life, and experience have been used without any effort to define them. Complete critical definitions of these terms presuppose a knowledge of the results of psychological study, for it is the function of psychology to ascertain the characteristics of consciousness. In the meantime, there is no danger of confusion in the preliminary use of the terms. Consciousness is what each one of us has when he sees and hears, when he feels pleasure or sorrow, when he imagines or reasons, or decides to pursue a line of action. Experience is a general word which may conveniently be used to cover the same group of facts. Stones do not experience impressions or emotions. Man, on the other hand, lives in a world of experiences. His inner life is not made up of

objects, but of experiences of objects. Whenever we think, or remember, or try to understand an object presented to the senses, we have an experience. As pointed out in the discussion of introspection, conscious processes may be distinguished from other facts by the possibility of self-observation or introspection, by which method alone these conscious facts can be directly observed. Facts of external reality are open to general observation by many different individuals; conscious experiences are purely personal, open to introspective observation only. We sometimes express the contrast between the facts of conscious experience and the facts of external reality by the use of the terms subjective and objective. Whatever belongs exclusively to the world of experience is called subjective. Thus, ideas and feelings are subjective. The facts with which physics and chemistry deal are not exclusively subjective; they have objective, external characteristics. Indeed, physics and chemistry are interested in facts only in so far as they are objective. For these natural sciences the subjective ideas of the individual physicist or chemist are merely the means to an end, which end is the intelligent comprehension of the objective world. The same antithesis which is expressed by the terms subjective and objective is expressed by the terms psychical facts and physical facts. The former are the directly known conscious processes, the latter are the facts of the external world as known through the senses and as studied in the objective sciences. These remarks on the various terms which are used in defining the sphere of psychology serve to indicate, in a sufficiently unambiguous way, the direction in which our studies must turn.

CHAPTER II

THE EVOLUTION OF THE NERVOUS SYSTEM

Objective method applied.

THE discussion of methods presented in the last chapter furnishes ample justification for beginning the study of psychology with an examination of the external conditions and accompaniments of consciousness. The most important condition of consciousness is to be found in the proper functioning of the nervous system. The person who faints and loses consciousness because the blood supply to the brain is cut off, gives a striking illustration of the intimate relation between the action of the nervous system and consciousness. Other examples of this relation can easily be supplied from ordinary experience. A blow on the head, excessive physical fatigue, and a great variety of less extraordinary conditions in the nervous system, affect conscious experience in unmistakable fashion. Such facts as these point to the nervous system as one of the first objective conditions of consciousness which should be studied in psychology.

Functions of unicellular animals.

If we descend the scale of animal life to the lowest forms, we find that they have no nervous system. Indeed, they have no organs of any kind. The whole body consists of a single cell made up of a nucleus and a surrounding microscopic mass of protoplasm. Such a unicellular animal is capable of moving about by contracting its tissue; it is capable of reproducing itself by cell division; it is capable of digesting food and throwing out waste matter; and, finally, it is irritable when acted upon by external forces. When one examines life reduced to such low terms, he realizes more fully than he is likely to realize when examining higher forms, how thoroughly interde-

pendent are all the phases of an animal's life. Consider how impossible life would be without the new supply of energy which comes through digestion; how limited in scope life would be without movement to bring the animal to new sources of food and carry it out of danger, or without cell division to increase the number of members in the species; and how utterly out of contact with the rest of the world the individual would be without irritability. The fact that all these functions appear in the simplest unicellular forms shows how fundamental they are.

The simplicity of the movement function in unicellular animals.

If any one of these functions of a unicellular animal is examined closely, it will be found that it is very simple. Take, for example, the function of movement. The unicellular animal represented in Fig. 2 has three forms of movement. It swims forward, taking up food particles on its way, or it moves backward and then turns in an aboral direction, when stimulated by some violent stimulus, such as excessive heat or an acid in the water. If it is forced by its environment to execute the backward or aboral movements which are relatively unusual, it begins as soon as the short movements are over to swim forward, as at first. A life made up of swimming forward or moving rapidly backward out of the way of some strong stimulus is very meager in its possibilities, as will be realized when such a life is compared with the life of one of the higher animals, in which manifold movements are provided for in the highly developed and complex organs of locomotion. Between the function of movement as exhibited in this simplest form and the same function as exhibited in the highest animals, there is a long course of development, but this development consists solely in differentiation of movements, in refinement of adjustment and organization, not in the production of a wholly new fact of life. Indeed, we understand movement better when we learn by the study of the unicellular forms that there are two fundamental types of movement, — one forward in the search for food, and the other backward for protection. Even in the highest animals these fundamental movements reappear as typical forms.

Primitive irritability.

Like movement, irritability is at this stage of animal life very little differentiated. There are no special organs for the reception of sound or light or any other form of energy. All forms of energy acting upon the same simple body structure must produce effects of a character much more nearly uniform in quality than are the effects of the same forms of energy on an animal supplied with separate and highly developed organs of sense. If one tries to imagine what the effects of irritation are like in such an animal, he must resort to certain analogies and consider his own experiences of pressure which are relatively undifferentiated, or better the sensations from the viscera which have very little specific character to distinguish them from one another. These analogies give some rough general notion of the character of primitive undifferentiated irritability. In spite of its

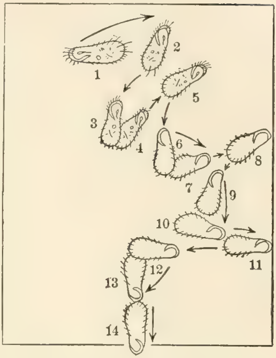

Fig. 2. Figure and explanation from Jennings. The figure represents one end of a slide which is heated from above. A unicellular organism, Oxytricha, in the position *1* is reached by the heat coming from the upper part of the slide. The animal reacts by turning to the right and backing (*1, 2, 3*), turning again (*3–4*), swimming forward (*4–5*), backing (*5–6*), turning again to the right (*6–7*), etc., till it comes against the wall of the trough (*8*). It then reacts as before, by backing (*8–9*), turning to the right (*9–10*). This type of reaction continues as long as the Oxytricha is in the heated region, or as long as its movements carry it either against the wall or into the heated region. When it finally becomes directed away from the heated region (*13*), as it must in time if it continues its reactions, it swims forward, and since it is no longer stimulated, it no longer reacts.

lack of differentiation, irritability, even in its lowest stages, serves to keep the animal adjusted to its environment. Let light fall upon the water in which a number of the simplest animal organisms are swimming and some species will collect in the darkness, others in the light, in such numbers as to indicate clearly in either case that they are affected by the light. Again, pressure due to contact with external objects, and vibrations of the water, are effective in producing more or less intense movements in animals of all grades of development. Irritability is, as contrasted with the other functions of the unicellular animal, the guiding function. Furthermore, it is related from the very first to contractility or the ability to move. The ability to receive impressions and the ability to respond to impressions by movement have here, and all through the animal kingdom, a parallel development. Of what value would it be to a unicellular organism to have elaborate functions of movement, while its ability to receive impressions is not sufficiently developed to guide it in intricate forms of behavior? Of what value would highly differentiated sensory functions be with an extremely limited range of responses?

Characteristics of primitive irritability.

The study of unicellular organisms leaves us, then, with four important general facts on which to base our study. Irritability is a fundamental function of even the lowest forms of protoplasm; it is at first undifferentiated; it is a function of the greatest importance in guiding the animal in its responses to its environment; and, finally, it is from the first intimately related to the function of movement.

Specialization of functions in multicellular organisms.

Turning now from the unicellular animal to a form somewhat higher in the scale, we find that structurally the more highly developed animals are characterized by the fact that their bodies, instead of consisting of a single cell, consist of an aggregation of cells; this we express by the statement that they are multicellular organisms. Figure 3 represents a section of a simple multicellular animal which lives in fresh water and is known as a hydra. The animal is sack-

shaped, with a mouth opening and tentacles at its upper end. The figure shows the walls of the sack-shaped body much magnified. The inner lining of this wall is made up of a layer of cells which are specialized to perform the function of digestion. The outer wall is specialized in certain of its cells for the reception and transmission of stimulations, and in other cells for the performance of movements. The processes of reproduction are provided for at special points in the body wall as indicated at *R, R, R, R,* in the figure. Between the inner and outer layers there is an intermediate layer of tissue, in which cells sometimes appear from one of the primary layers. The intermediate layer is not sufficiently developed to constitute a separate series of organs. This multiplication of cells and specialization of functions is a process which has advantages familiar to any one who has observed the analogous fact of division of labor in social organizations. The cells of the body set apart for special purposes do not lose the general characteristics which belong to all living protoplasmic cells. For example, all the cells of the body absorb the necessary nutrition to support their individual lives, but the cells outside of the digestive layer do not take their nutrition from the

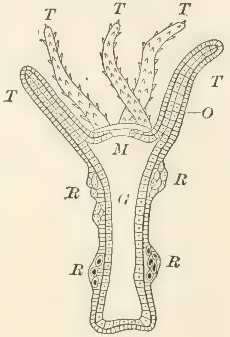

FIG. 3. The hydra. The figure shows a section through the body and exhibits the two cellular layers with a neutral layer between. The general body cavity, *G*, is lined by cells which are devoted entirely to the special function of digestion (the mouth opening is at *M*). *R, R, R, R* are the reproduction cells. The outer wall of the body is made up of muscle cells and specialized sensitive cells. *T, T, T,* are the tentacles. Adapted from Haller.

external world; they derive it from the digestive cells which alone perform the special function of digesting foreign particles. So, also, with the function of irritability. This is not lost by the specialized contractile cells and digestive cells; it is merely reduced in these cells to a very low point and is very highly developed in the specialized sensitive or irritable cells, so that the movement cells or muscle cells and all other parts of the body come ultimately to receive their impressions from the outer world, not directly, but through the neural or sensory cells. The neural cells thus specialized to receive impressions are placed in the outer body wall, where they are in the most favorable position to be acted upon by external forces, or stimuli as forms of energy which affect the nervous system are technically called. The specialized nerve cells develop a more complex chemical structure than the other cells of the body, so that they are more easily set in action by external forces. They are, accordingly, highly important, but by no means independent factors in the organic economy. They are developed, not for some remote and separate life of mere irritability or sensitivity, but as essential parts of the developing organism, in which they control and direct all the animal's activities so as to adapt the animal to the world in which it lives.

Differentiation of neural cells. Even in the simple organism under consideration, the process of specialization has advanced so far that there begin to appear various classes of neural cells, each serving a special function. Certain of these cells serve the direct function of receiving impressions from the outer world, and are known as sensory cells, while others serve the function of transmitting the impulse to the muscle cells. Figure 4 shows how the two groups of irritable cells are related to each other and to the muscle cell.

Nature and function of a neural process. The process which goes on in the neural cells may be described as follows: Some form of external energy acts upon the cell. The external energy as noted above is called a stimulus. This sets up a chemical process in the cell which is known as a pro-

cess of excitation or a stimulation. The process of excitation liberates energy which was stored up in the cell. This liberated energy is transmitted to other cells in the body, either to the secondary transmitting neural cells or to the active contractile cells. This current of nervous energy has been compared to an electric current. It is, however, much slower than an electric current, its rate of transmission being in the higher animals about one hundred meters per second or less. We do not know its exact character, but probably it is more like the succession of combustions which takes place along the line of a fuse of gunpowder. Our ignorance of the exact nature of the nervous current need not delay the discussion, however, for we shall find that the importance of nervous currents for our further study depends upon their paths of transmission rather than on their nature. The path of transmission will be determined primarily by the direction and connections of the fibers which unite the cell in which a given excitation originated with other parts of the body; secondarily, the path of transmission will depend. on the fatigued or unfatigued condition of the cells and on the other currents of energy which are flowing through the system at the same time. All these complex possibilities may be summed up in the statement that in its transmission through the neural organs every nervous excitation is directed and is combined with other impulses, and is ultimately determined in its effects by its path of transmission and its relations to other impulses, quite as much as

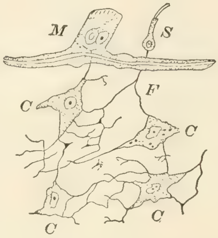

FIG. 4. Much enlarged section of a muscle cell and a sensory cell of a hydra, together with the connecting cells which lie between them. *M*, muscle cell; *S*, sensory cell; *C*, intermediate cells; *F*, fiber connecting the sensory cells with the central cells. Adapted from Haller.

by its own quality and intensity. Furthermore, as soon as it is recognized that nervous impulses consist in currents of energy which have been liberated by the stimulus, it will be recognized that every nervous current must produce some effect before it is dissipated, for a current of energy must do some work, it cannot disappear. The effects produced by nervous impulses are of two kinds. First, the energy may be absorbed in the course of its transmission, in which case it will produce changes in the condition of the nervous tissue, thus contributing to the modification of the structure of that tissue. Second, it may be carried to the natural outlet of all nervous excitations; namely, the motor channels leading to the muscles or other active organs of the body. It will there produce some form of muscular or glandular activity. If it contributes to changes in structure, these changes in structure will ultimately influence new incoming impulses which are on the way to the active organs. We may, therefore, say that directly or indirectly, all incoming nervous impulses are transmitted to the active organs of the body after being more or less completely redirected or partially used to produce structural changes in the nervous organs.

Sensory, central, and motor processes.

The range of nervous processes possible in the simple structures of a hydra is extremely limited; for this very reason the fundamental characteristics of nervous processes are all the more apparent. We can distinguish clearly the first step which is the reception of the external stimulus. This first step is commonly described as a sensory nervous process. The cell on which the stimulus acts is a sensory cell. The intermediate cells placed between the sensory cell and the muscle are called central cells. The fibers passing from the central cells to the muscle are motor fibers. It will be seen that the sensory, central, and motor processes cannot be sharply distinguished from each other; they are all phases of a single continuous process, the end of which is always some muscular activity.

When we turn from the hydra to the higher forms

Evolution of nervous organs in the directions of centralization and differentiation.

of life, we find that the multiplication of cells and the specialization of functions leads to the most elaborate organizations. Without attempting to deal with the other systems of organs, we may note that the nervous organs develop in two directions. There is, first, a grouping of the central cells into complex central organs and, second, a differentiation of the receptive or sensory cells resulting in the production of special organs for the reception of a great variety of stimuli such as light, sound, tastes, odors, and other forms of energy. These two types of development may advantageously be considered in succession. For the remainder of this chapter, the differentiation of the sense organs will be passed over and the evolution of the central organs will be briefly sketched.

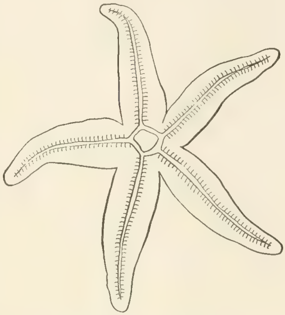

Fig. 5. Outline of a starfish and nervous system of the same. Each arm of the starfish is supplied with a series of nerve cells indicated by the lines passing through the various arms. From these nerve cells, fibers extend to the surface and receive sensory impulses and send out motor impulses. From Loeb.

Centralized nervous systems.

The nervous system of the hydra is scattered diffusely throughout the body wall; there is no special part of the body in which the central cells are massed. The higher animals all have a more or less highly centralized nervous system. A simple type of centralization is seen in the starfish. Figure 5 shows the general outline of this animal's body and by the lines within this outline the distribution of the central nervous cells. Each double line represents a group of cells. It will be seen that there is a central system of cells for each arm, to which sensory impulses pass from

the surface of the body and from which motor impulses return to the muscles. There is also a central ring which binds together the different arms and centralizes in a still higher degree the whole animal. This ring is in the neighborhood of the mouth opening, and its function is undoubtedly connected with the highly important function of controlling the whole animal in taking food. Another type of centralization appears in any one of the segmented animals such as an insect. Figure 6 shows such a centralized nervous system. Each segment has its group of central cells, and all the segmental centers are related by connecting fibers to one another and to the highly developed group of cells in the first segments, which are near the mouth opening.

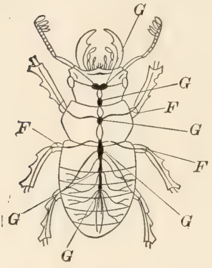

FIG. 6. A stag-beetle showing the outline of the body and the distribution of the nerve cells and fibers. Each segment of the body has a ganglion of cells *G*, *G*, *G*, from which fibers *F*, *F*, *F* are distributed to the surface of the body for the reception of stimulations and the distribution of motor impulses. The ganglion in the front section of the body is double and of greater importance than those in the posterior segments.

Complex activities provided for in centralized nervous systems.

The importance of this highly developed, centralized nervous system becomes evident the moment one begins to study the behavior of the animal. Take, for example, the bee, and note its movements. It exhibits the most elaborate forms of activity, including locomotion, the act of stinging, the various acts connected with the taking of food, caring for the young, and storing up supplies for the support of individual life. This indicates that there are complex paths in the nervous system of the bee, such that external stimuli set in action complex systems of redistribution and motor discharge. Furthermore, it

will be noted that the behavior of the bee is not only complex; it is developed in many of its details at the beginning of life. The young bee is endowed with the ability to fly as soon as it unfolds its wings. It does not learn to sting by any long process of practice. It is capable of doing all of these acts from the first. When certain stages of bodily maturity are reached and certain external conditions, such as those of temperature are favorable, bees are capable without previous training of going through the most elaborate performances, such as swarming or making cells in which to deposit their eggs. This complete determination of the bee's behavior depends upon the existence of inherited paths of connection laid down in the structure of the bee's nervous system at the beginning of its life. Individual experience does not modify its modes of behavior, for there is no part of its nervous structure which is left undeveloped at the beginning of its life, to be mapped out in the course of individual contact with the world.

The probable character of primitive consciousness.

The characteristics of such a nervous organization are undoubtedly reflected in the animal's consciousness, if we may hazard a guess as to the kind of experience which such an animal can possess. There can be none of the discriminating experience which higher animals have when they stop before some object and study its properties. The analogy which we should borrow from human experience, if we would understand the experience of a bee, is the analogy of a fully organized habit, or better, the analogy of one of our own inherited modes of action, such as that exhibited in the winking of the eye or jerking the head aside when an object moves rapidly toward the face, threatening to strike it. Conscious experience is made up in such cases, not of clearly defined knowledge of the thing which gives rise to the experience, but rather of a vague excitement, followed by unrest, if the instinctive winking or dodging does not adequately meet the requirements of the situation, and by satisfaction, if the activity proves sufficient.

The view thus taken of the nature of primitive con-

Relation between behavior, nervous structures, and consciousness.

sciousness illustrates the general principle that an intimate relation may always be sought between nervous organization, behavior, and consciousness. The movement which an animal makes, or its behavior, depends on the way in which nervous impulses are distributed to its muscles. The conscious experience which the animal has, is related to the way in which impressions are received and utilized. The result of this interrelation is that in scientific studies inferences are continually being made from one group of facts to the other. Most common in ordinary life is the inference from behavior to consciousness. We say a man acts intelligently or inconsiderately. We say that an animal acts without deliberation or thought. Indeed, we should have little justification for any assertions whatsoever regarding animal mental life, if we were not prepared to recognize the relation between behavior and experience. The common observer does not know the facts of nervous organization, hence the inference from nervous organization to consciousness is not so common as the inference from behavior to consciousness. It is the purpose of our scientific study to justify and establish the inference from nervous structure and behavior to consciousness. This is the reason why psychology takes up the study of nervous structures, and it is in this possibility of inference from nervous structures to consciousness that psychology finds one of its most fruitful fields. It need hardly be added that when we reach the level of human life, the reverse line of inference from consciousness to nervous organizations is one of the indispensable accessories to the scientific study of nervous processes.

Invertebrate nervous systems.

Returning from our digressions, we may continue the study of nervous structures. Among the invertebrates there is the greatest variety in the form and complexity of nervous structures. In all cases, however, these structures are essentially like those of the insect shown above. They are all organized with reference to a highest center and completely mapped out at the beginning of life into tracts for the control of instinctive activities.

Frog's nervous system; lower centers.

Passing by long steps up the scale of life, we may next consider the nervous system of one of the lower vertebrates. Here we find that the centralized organization has gone beyond that seen in the insects, but it is yet relatively simple. Figure 7 shows the general form of the frog's nervous system looked at from above. In all of the vertebrates the nervous system is incased in the bones of the vertebral column and skull, so that the view here presented shows the appearance of the nervous organs after the bones and muscles and skin which cover these organs in the normal animal have been removed. The frog's nervous system may be roughly divided into two main sections. The first part lying below the cerebellum consists of the long cylindrical spinal cord with the medulla, which is essentially an enlargement of the cord, at its upper end. The cord and medulla are directly connected with the surface of the body by means of a great number of fibers. The in-

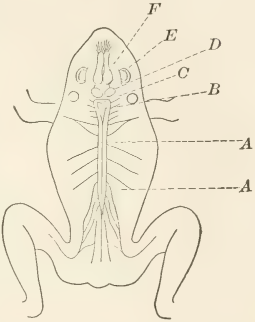

Fig. 7. Shows the nervous system of a frog as it would appear if the skin and muscles and protecting bone were removed. *A*, spinal cord with some of the nerve fibers which extend from this organ to the surface of the body. In the posterior region a plexus of fibers extends to each of the posterior extremities; in the anterior region, a plexus extends to each of the anterior extremities. *B*, medulla; *C*, cerebellum; *D*, optic lobes, which are connected with the eyes by optic fibers which pass underneath the brain; *E*, optic thalami; *F*, cerebral hemisphere. The anterior portions of the hemispheres constitute what are known as the olfactory lobes. These lobes are directly connected by means of the fibers shown in the figure with the olfactory region. Many of the nerve fibers which extend from the medulla to the surface of the body are omitted in this drawing.

coming sensory impulses from the skin are received through certain of these fibers, and motor impulses are distributed to the muscles through others. There are many cells in the cord and medulla, their chief function being to form links of connections between the incoming sensory fibers and the outgoing motor fibers. If the cord and medulla are separated from the higher centers by a cut just below the cerebellum, the processes of movement in response to sensory stimuli applied to the trunk and legs go on with very little departure from the normal, the only difference being that activities called out by these stimuli show a machine-like regularity quite foreign to the normal animal. While the cord and medulla can thus be shown to be relatively self-sufficient organs, they are under normal conditions connected with the higher centers by fibers which run up and down through the whole nervous system. By means of these connecting fibers the action of the cord and medulla is subordinated, as were the functions of the segmental centers in the bee, to the requirements of the whole animal, as dictated by the highest centers around the mouth.

Frog's nervous system; higher centers.

The centers above the cord and medulla, which constitute the higher group of structures in the frog's central nervous system, are of two kinds. There are, first, certain sensory centers; namely, the large optic lobes and the olfactory lobes. These connect respectively with the eyes and nose of the frog and receive sensory impulses from these higher senses. The large size and forward position of these two centers indicate the importance of the functions which they perform in the animal's life. Especially, the large size of the optic lobes is directly related to the fact that the frog uses its sense of sight in capturing the insects on which it subsists. Besides the sensory centers mentioned, there are in the higher parts of the nervous system a series of organs; namely, the cerebellum, the thalami, and those parts of the cerebral hemispheres which lie back of the olfactory lobes, all of which are centers for the working over of

stimulations received in other parts of the nervous system. These last-mentioned centers do not connect directly with organs of sense or with muscles; they operate at a higher level, evidently performing some function higher than that of direct reception and discharge of stimulations.

Association centers and processes of organization.

Certain of the functions of these higher, indirect centers may be described as functions of association. Impulses received in the cord and medulla are related in the higher centers to impulses received in the optic and olfactory lobes, and the action of the animal is determined not by single sensory processes, but by all the sensory processes after they have been united into elaborate associative complexes. Thus, a frog stimulated at once by a tactual and a visual stimulus will react, not to one without reference to the other, but rather to the combination of the two. An animal with large centers for the indirect elaboration of impulses exhibits, accordingly, a very much greater independence of single stimuli than does an animal with a simpler nervous system, because the association processes subordinate the single impulses to the general demands of impulses from all parts of the organism.

Higher organizations less determined through inheritance.

There is another important change which comes with the development of large association organs. The animal is less completely determined in its behavior through inherited structures; more of the organization of its activity is left to be worked out in the course of its individual contact with the world. The direct centers in the lower organs provide sufficient tissue for the hereditary transmission of the fundamental instinctive organizations necessary to maintain life, such as the movement of swimming or turning over when the animal is placed on its back, but such activities are subordinated in all the more highly developed animals to organizations which are developed in the association areas during the course of individual life.

In certain respects the organs of the nervous system are all alike. They all transform sensory impulses

Association areas characteristic in man.

into motor impulses in the same fundamental way as the nerve cells of the hydra transform sensory stimuli into motor processes. It is true of the association areas of the frog's brain as of the direct centers in the cord and medulla, that sensory impulses are there transformed into motor processes. Too much emphasis cannot, however, be laid on the fact that the injection of an indirect process of organization into the sensory-motor circuit transforms the process to such an extent that after the new, indirect mode of organization appears, it dominates the whole nervous activity as well as the whole life of the animal. The higher animals are not characterized by their lower nervous centers nor by their organs for the reception of sensory stimuli. Far down in the scale of the vertebrates, the cord and the medulla reach a high stage of development, and the organs of sense attain a degree of perfection which makes them comparable to the corresponding organs in man. The whole matter can be emphatically stated by comparing man with the lower vertebrates. Man is not distinguished in his nervous organization from the animals below him by a notably better set of sense organs or a better spinal cord and medulla. We shall look in vain in these organs for the structural conditions of man's superiority in forms of behavior and in intelligence. Man's higher faculties are related rather to the vastly higher development of indirect nervous centers, in which the incoming sensory impulses are associated with each other and redistributed so that they come to be organized in the most elaborate fashion.

Evidence from comparative anatomy.

The significance of the association areas will become obvious if we examine a series of figures illustrating the progressive evolution of the nervous system from the frog to man. The best view from which to exhibit these facts of development is the lateral view shown for a number of different levels of vertebrate life in Fig. 8, *A*, *B*, *C*, and *D*. One cannot fail to be impressed by the fact that cord, medulla, optic and olfactory lobes remain practically stationary in rela-

tive size throughout the series, while the thalami, the cerebellum, and especially the cerebrum, develop to relatively enormous organs. The behavior and experience of the higher animals stand in the closest relation to these striking developments in the nervous structures.

Complexity of structure is paralleled by complexity of behavior.

Without attempting to exhaust the subject at this time, we may note certain salient characteristics of behavior which distinguish the higher animals from the lower. First, the variety of movements is vastly increased. Up to a certain point in animal evolution the number of organs of movement, of limbs and oral muscles, for example, increases to meet the increasing needs of the animal; but ultimately a point is reached where development of movement goes forward without any corresponding development of new limbs or muscles. This later stage is characterized by the development of nervous structures which make it possible to use the given muscles in a greater variety of combinations, just as a skilled artisan depends for his perfected movements, not on the development of new arm muscles or finger muscles, but upon the development of finer coördinations of those muscles which all human beings possess.

Experiments to show significance of higher centers.

A second striking fact of behavior which parallels the development of complex nervous centers is that slight stimuli may set up the most elaborate processes. The value of the stimulus in such a case is determined, not by the intensity or quality which it has in itself, but by the complex organization which it arouses to action. Conversely, a strong stimulus may be absorbed in the elaborate organization and produce no immediate effect. These statements can be illustrated by the behavior of a frog under two groups of conditions, one of which is experimentally induced. If we cut off the frog's spinal cord and medulla from the higher centers, the frog will continue to live in a condition in which all the association activities are absent. If, now, we apply a stimulus to the skin of the frog's trunk, a response will follow immediately with mechanical regularity. This re-

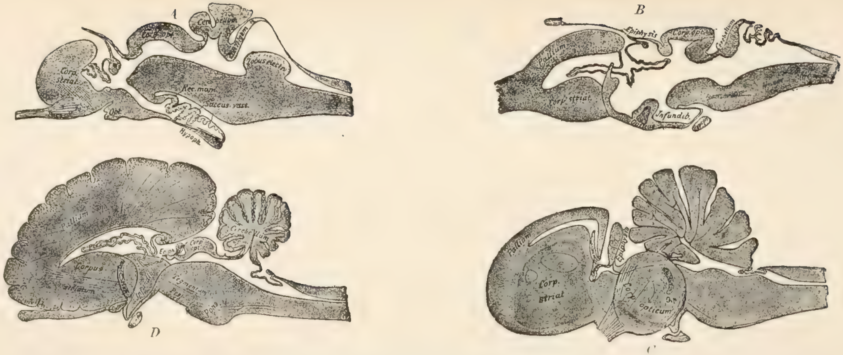

FIG. 8. *A*. The median section through the brain of a fish, showing the relative sizes of the different parts. It will be noted that the cerebrum is represented by the corpus striatum and pars olfactoria only, there being no cerebral cortex or pallium. The cerebellum is well developed. The corpus opticum is large and the lower portions of the brain, namely, the medulla and spinal cord, are of about the same relative size as in the higher forms.

B is a median longitudinal section through the brain of an amphibian. The same general size is given to each of these figures, though the absolute size of the various brains is different. It is to be noted especially that the front part of the brain has developed more than other parts. There is a pallium or cerebral cortex. The other parts maintain a relative size comparable to that in *A*. At the left the figure passes into the olfactory fibers, which are not here fully represented.

C is a section through the brain of a bird. The cerebellum is here very fully developed. The corpus opticum is entirely covered by the cerebellum. There is a large pallium and a large corpus striatum. These two constitute together a cerebrum which is obviously of much greater importance than the cerebrum in either *A* or *B*.

D is a similar section through the brain of a mammal, showing the general relations which appear also in the human brain. The medulla and lower parts of the brain, including the corpus opticum, have changed very little in relative size as compared with *A*, *B*, *C*. The cerebellum is well developed but not very different from that of the bird. There is a large corpus striatum. The very great development of the pallium or cerebral cortex is, however, obviously the most striking characteristic of this brain. From Edinger.

sponse will be of a very simple and direct type, usually consisting in a movement of one of the legs up to the point of irritation. In a second case, we may apply the same stimulus to a frog in which the cord and medulla are connected with the higher centers. The reaction in this case will be of an entirely different character. It will usually not come immediately, and its form will depend on a great variety of complex conditions. Thus, the frog may jump away, it may croak, or there may be a complete absence of apparent reaction. If such results as these appear in so simple an animal as a frog, the complexity of possible organization in a human being can be imagined.

Individual experience affects higher organizations.

Third, as perhaps the most important result of the development of indirect nervous centers, the impressions and activities which appear in the course of individual life enter very largely into the determination of nervous organization. As pointed out above, the lower direct centers are in the main determined in structure by heredity, the higher centers are left undeveloped at birth, so that the stimuli which act upon the individual find at the beginning of life a mass of undeveloped tracts through which they may be transmitted. It has long been recognized that the infancy of all the higher animals, especially human infancy, is very much longer than the infancy of the lower forms. The reason for this appears as soon as we recognize that the higher centers of the nervous system are not mapped out by heredity, and require time to mature. They develop under the stress of individual contact with the world. It is during this process of organization of the higher centers that conscious experience arises in the animal kingdom. There can be no question that the development in the nervous system of indirect centers is the direct physiological condition for the form of consciousness with which we are familiar in our own experiences. The nervous processes in the spinal cord and medulla are, so far as we know, accompanied by little or no consciousness. It is in connection with cerebral processes that consciousness, at least in its most vivid form,

arises. The rise of consciousness is, accordingly, related to the development of the elaborate nervous structures which constitute the indirect or association organs. These structures have been gradually evolved through specialization and centralization. Their function is obviously one of organization, and their dominant position in the organism indicates their importance in the life of the individual.

The following table may serve to indicate the general lines of evolution which have been traced in the foregoing discussions:—

	Lowest Forms	Hydra	Intermediate Forms	Highest Forms
Body	Unicellular	Very simple multicellular	Increasingly complex	Most complex
Nervous System	None	Specialized cells diffused through wall of body	Organized and centralized	Characterized by the addition of association centers
Organs of Sense	None	Very little, if indeed at all, differentiated	Increasingly differentiated	Further differentiated, reaching complete development early
Behavior	Simplest	Simple	Grows more and more complex	Most complex
	a, limited in variety	*a*, increasing in variety as compared with unicellular forms	*a*, shows variety of instinctive acts.	*a*, specialized movements of great variety
	b, made up of single acts	*b*, made up of simple series	*b*, made up of combinations of factors	*b*, long coördinated trains

	Lowest Forms	Hydra	Intermediate Forms	Highest Forms
	c, unmodified by experience	*c*, unmodified by experience	*c*, somewhat, though very little, modified by experience	*c*, guided chiefly by experience
	d, follows very directly on stimulus	*d*, direct	*d*, for the most part direct, but in higher forms includes indirect or memory factors	*d*, chiefly indirect, as shown in man in such activity as speech
Type of Experience		At most, vague feelings	Possibly vague recognition of those objects which call for instinctive reactions, but chiefly emotional	Instinctive recognitions and feelings present, but overlaid by intelligent consideration

CHAPTER III

THE HUMAN NERVOUS SYSTEM

The general description of the vertebrate nervous system given in the last chapter prepared the way for a more minute examination of the human nervous system.

Sensory and motor roots of spinal nerves.

The spinal cord is a cylindrical mass of nervous tissue about forty-five centimeters long and about one centimeter in diameter. It extends throughout the whole length of the vertebral column, occupying a canal which lies in the centers of the vertebræ. The cord is connected with the surface of the body by thirty-one pairs of nerves symmetrically situated on the right and left sides. These nerves are each made up of many fibers, some of which are sensory, others motor. All of the fibers are gathered together into a single bundle as they pass through the body. In the immediate neighborhood of the cord, they divide into two so-called roots. The motor fibers constitute one root and leave the cord on the ventral side, while the sensory fibers constitute the second root and enter on the dorsal side. This difference in the points of exit and entry of the two kinds of fibers shows at once that the tissues within the spinal cord are divided into parts, the parts being determined by the functional character of the elements.

The element of all nervous structures is the neurone.

The structural elements of the spinal cord, like the elements of all parts of the nervous system, are neurones or cells of a highly specialized structure. Each cell is made up of a nucleus, a cell body of protoplasmic tissue surrounding the nucleus, and a series of processes extending from the cell body. The processes are of two varieties; namely, dendrites or branching arms, which usually conduct impulses

toward the cell body, and a single long nerve fiber which carries the impulse outward from the cell body. Cells in the cord are usually large as compared with other nerve cells in the body, though absolutely considered they are minute microscopic objects, the largest being about one tenth of a millimeter in diameter. Figure 9 shows two neurones with all their characteristic parts. It will be noted that the long fiber is made up of several parts. There is a sheath in most of the long fibers of the nervous system. This is not an essential part of the nervous structure, but is an external growth which protects the inner nervous thread or axis cylinder, as it is called, and doubtless acts as an insulator.

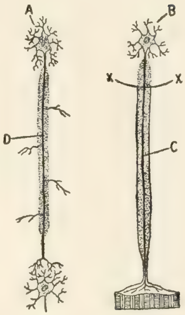

FIG. 9. Two nerve cells (*A* and *B*) are here represented with their axones *C* and *D*. *C* extends from the cell to a muscle; shortly after leaving the cell the axone is surrounded by a heavy protecting sheath, as indicated in the figure, and known as the medullary sheath. At *XX* there appears an outer sheath known as the Sheath of Schwann. The medullary sheath ends at the point where the fiber divides into a fine network and passes into the muscle. The axone *D* communicates with another cell. From Testute.

Nature of synaptic connections.

In the cord, as in other parts of the nervous system, the neurones are organized in systems of chains. An impulse acting on one cell is transmitted to other connected neurones until finally the impulse reaches a cell connected with a muscle fiber. The contact between neurones in the higher nervous systems is indirect, as shown in Fig. 10; that is, the fiber from one cell does not pass directly into another cell, but breaks up into a fine network of fibrils and interlaces with the dendrites from other cells. The connections of a single cell may be very numerous by

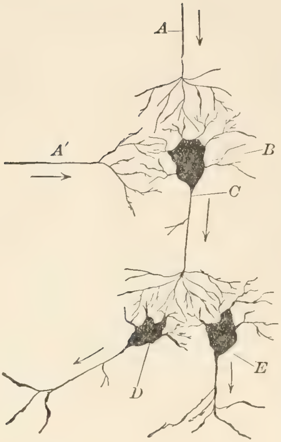

Fig. 10. A number of different types of connection between nerve fibers and cells are here represented. *A* and *A′* represent incoming sensory fibers which bring stimulations from different directions to the cell *B*. All of the stimulations acting upon *B* are transmitted along the fiber *C*, and at the end of this fiber may affect various cells, such as *D* and *E*. From the cells *D* and *E* the stimulations may pass in different directions, as indicated by the arrows. The stimulations from *A* and *A′* fuse in the cell *B*. The stimulation from the cell *B* is subdivided and redistributed from *D* and *E*. All connections are indirect or synaptic.

virtue of the branching of the dendrites and the indirect relations between neurones. The point of relation between two neurones is known as a synapse. At the synapses, impulses are redistributed in the greatest possible variety of directions.

Significance of the branches of neurones.

An examination of neurones in various animals and at different stages of individual development shows clearly that the number of branches of the cell is an important factor in determining the complexity of the nervous organization into which the neurones may enter. Figure 11 shows the increasing complexity of neurones as we ascend the scale of animal life, and also the increasing complexity of neurones of a single human being as the nervous structures mature. The lesson to be learned from these two series of figures is clear. The complexity of a cell and the number of systems of connections into which the cell may enter, increase in direct proportion to each other.

When the cell has few branches, the possibility of its entering into relations is limited to a small number of definite tracts. To this statement should be added another, which will be found later to be of importance in explaining certain irregular modes of nervous activity. When there are no definite lines of connection between neurones or when the nervous impulses are so intense as to overflow the regular channels of conduction, a diffuse transmission of nervous energy may take place. Neurone will then affect neurone without reference to definite dendrites or axis cylinders. Diffuse stimulations may, therefore, be regarded as the most primitive forms of interconnection. The higher the animal and the more completely developed the individual, the more complex the definite tracts provided for in the dendrites, and hence the more elaborate the definite organizations. The fewer the dendrites, the fewer the definite paths of conduction.

FIG. 11. Shows the development in complexity of nerve cells in the course of animal evolution and in the course of the development of a single individual. *A* is the nerve cell of a frog; *B*, a lizard; *C*, a rat; *D*, man. The possibility of developing definite paths between various neurones increases in proportion to the increase in the number and complexity of the dendrites from the cells. *a* is a neuroblast without dendrites from the earlier embryonic development of a human brain. *b* shows the beginnings of dendrites at the upper end of the cell. In *c*, in *d*, and in *e* the dendrites increase. The form of the mature cell can be seen by referring to *D* in the upper series. From Cajal.

Interruption of synapses results in diffusion.

The significance of the synaptic connections in the nervous system becomes very clear when the mature nervous system is affected in such a way as to disturb these connections. Certain drugs and such conditions as sleep serve to interrupt the regular synaptic paths. The

result is that the behavior of the muscles is very irregular, sensory impulses are much diffused, and the conscious experience of the individual becomes diffuse and irregular.

Anatomy of nervous organs depends on connections of neurones.

After this general study of neurones and their modes of connection, we are prepared to consider briefly the internal anatomy of the cord and the higher centers; for the minute anatomy of any part of the nervous system consists merely in the connections between the different neurones which constitute that part of the nervous system. It should, perhaps, be mentioned in passing that there are, in addition to the nerve cells in any one of the organs of the nervous system, a number of connective-tissue cells which bind together the true nervous structures so as to make a compact organ. These connective-tissue cells may be neglected, however, for the purposes of our present discussion.

Spinal cord, minute anatomy.

Figures 12 and 13 show diagrammatically portions of the spinal cord with the details of structure exhibited for several different levels. The sensory fibers coming from the surface of the body and bringing stimulations from the organs of sense in the skin, pass through certain large bipolar cells which lie just outside the cord, as indicated in the figures. A group of nerve cells, such as these bipolar cells, is known as a ganglion. The sensory roots of each of the spinal nerves has what is known as a posterior spinal ganglion. The cells of the spinal ganglion are relatively simple structures, as will be seen from the limited number of their branches. They will be referred to again in discussing the organs of sense in the skin, for they are the sensory cells of the tactual sense. Within the cord, the sensory fibers subdivide, certain branches passing upward and downward through the cord, others extending across the cord to communicate with other cells, which in turn send out fibers either to other levels of the cord or into the motor roots of the spinal nerves. If we confine our attention for the moment to the lateral branch of one of these fibers which extends across the cord at the

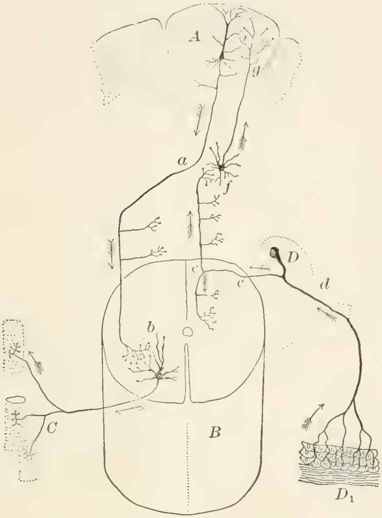

FIG. 12. A diagram to illustrate the course of the sensory stimulation when it passes upward from the level of the spinal cord at which it is received. *B* represents a section of the spinal cord; *A*, a portion of the cerebral cortex. D_1 represents a region of the skin in which the sensory ending of a tactual fiber from the cell *D* is distributed. A pressure stimulation acting upon D_1 will excite the nerve cell and send a stimulation inward, as indicated by the arrows. This stimulation will pass upward and downward to various levels of the cord, as indicated by the branching of the incoming fiber at *e*. Certain portions of this incoming stimulation will be distributed through the spinal cord at different levels, as indicated by the small collateral branches passing horizontally out of the branches of the sensory fiber. *See also* Fig. 13. At *f* the incoming fiber communicates with a nerve cell which in turn connects with the cortex. This diagram is probably much too simple, more than one cell being necessary for the transmission of this stimulation to the higher centers. When the stimulus reaches *g* in the cerebral cortex, it acts upon the pyramidal cell and is transferred into a motor impulse. It then passes downward along the fiber *a*, which gives off horizontal collaterals at different levels of the cord. Through one of these collaterals or through the termination of the centrifugal fiber, as indicated at *b*, the stimulus is transmitted to a motor cell in the spinal cord, and from this cell is carried outward to the muscles indicated at *C*. After Cajal.

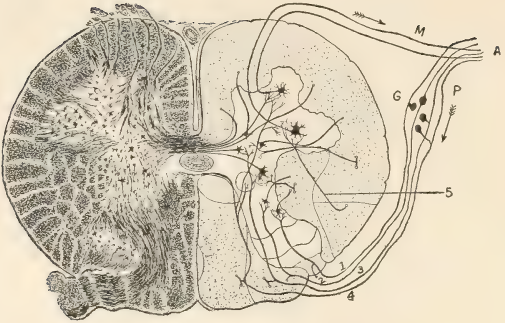

FIG. 13. Represents a transverse section across the spinal cord. The left-hand side of the figure represents the tissue as it would be seen in a section. The right-hand side of the figure is diagrammatic and shows the connections between the cells and fibers. The figure represents the white tissue by dotted areas, and lines. The dots represent cross sections of the fibers. The gray matter which occupies the central portion of the cord is represented in general outline by the central white areas and in more detail as to its structure by the nerve cells.

At *A*, a spinal nerve is represented as dividing into the two roots; the posterior root *P* which carries stimulations into the spinal cord, and the anterior root *M* which transmits stimulations from the cord to the muscles. The posterior ganglion *G* is made up of simple bipolar cells. The nerve fibers either pass directly through these cells or are connected with the cell bodies by branches, as represented in the figure.

Four typical sensory fibers are represented in the figure. Fiber No. 1 enters the cord, giving out a collateral branch which passes to another level, and can be represented in this plane only by a short line ending in a circle which represents the section across the fiber. The main fiber comes into synaptic relation with one of the cells in the posterior gray matter of the cord. This cell sends out a fiber into the white portion of the cord. The fiber then passes upward, as indicated by the small circle at the end of the fiber. Fiber No. 2 needs no special description. Fiber No. 3 gives out collaterals which extend upward and downward and are followed in greater detail in Fig. 12. The main fiber is carried inward and comes into relation with cells which send their fibers across the spinal cord to the opposite side. The

level at which the fiber entered, we see that incoming stimulations may be carried by a relatively short route to motor cells on the same side of the cord. These motor cells send out fibers to the muscles from the same level as that at which the sensory fibers enter. The figures illustrate cases which are probably much simpler than any case which actually appears in the human nervous system, but for the purpose of diagrammatic representation the figures are adequate. The motor fibers very soon join the sensory fibers, as has been pointed out above, making up a single bundle of fibers traveling toward the surface of the body. There is no anatomical connection, however, between the sensory and motor fibers in the nerve trunk. They travel to the surface in a single bundle, but each fiber is protected by its insulating sheath, and the stimulation which each individual fiber carries cannot be transmitted in the course of its passage to any other fiber. All relations between sensory and motor fibers depend upon connections between their central cells in the spinal cord.

Reflex arcs.

The direct path of transmission from sensory to motor cells in the spinal cord is known as a reflex arc. The significance of this term will be perfectly clear when one considers that the stimulus received

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general characteristics of Fiber No. 4 will be easily recognized. One branch of this fiber may be especially noted as the path of the simplest reflexes. This extends into the anterior portion of the gray matter of the cord, where it comes into synaptic relation with one of the large motor cells. This cell in turn sends its axone out of the cord into the spinal nerve *A*.

The long fiber marked 5 in the figure appears at this level of the spinal cord as the end of a fiber which has descended from a higher level. It comes into synaptic connection with a large motor cell in the anterior region. Other connections are indicated in the drawing. In the schematic representation of the fibers, or white portion of the spinal cord, certain lines are introduced, which indicate that the various groups of fibers have different functions. Connections of the nerve cells shown in the schematic diagram make it clear that the different portions of the gray matter in the cord also serve distinct functions. Adapted from chart by Strümpell and Jakob.

from the sensory fiber is immediately reflected back to the surface of the body, where it sets a muscle in action. Most stimulations received through the sensory fibers are not reflected back in any such simple fashion to the surface of the body. They are carried upward and downward to levels of the cord other than that at which they are received and their influence is complicated by a great variety of redistributions, before they can be returned to the muscles at the surface of the body.

Bilateral structure and connections of the cord.

A second type of connection, which may be noted in Figs. 12 and 13, is that which results in the transmission of the stimulation received on one side of the body to the motor cells on the opposite side of the spinal cord. The figures show that the spinal cord is a bilateral organ. An anterior fissure, a posterior septum, and a small central canal divide the spinal cord into two well-defined halves. There are bridges of fibers connecting these two halves, as indicated in Fig. 13. Across these bridges, or commissural connections, stimulations may pass from one side to the other, and thus the two sides of the body may be readily united in any form of action.

Longitudinal tracts in the cord.

An important type of transmission through the cord is that mentioned above and provided for by the branches of the spinal nerve, which extend upward and downward and make it possible for a single incoming impulse to set in action different levels of the cord.

The cord as subordinate to the higher centers.

All of the connections which have been discussed up to this point are reflex tracts. There is another type of connection in the spinal cord. The branches of the sensory nerves which extend upward, as well as certain other fibers which originate in the cells of the spinal cord itself and extend upward, bring the cord into relation with the higher parts of the nervous system. There are also fibers extending downward into the cord from the higher centers. These fibers from above bring motor impulses which are distributed to the muscles through the motor cells of the cord. The cord is, therefore, not merely a group of reflex centers; it is also a transmitting organ provid-

ing for communication between the higher centers and the surface of the body.

Gray and white matter in the cord.

The twofold function of the cord is closely related to the structural fact that the cord is made up of a central mass of cells and an outer layer of fibers. In a section of the cord the fibers are easily distinguished by their glistening white color, while the central tissue made up largely of cells is gray. The gray matter can be thought of as consisting of a series of nerve centers capable of simple reflex processes. The white matter contains the fibers which perform the transmitting functions of the cord. When, for any reason, the higher organs are incapacitated, the lower reflex centers become conspicuous by virtue of the fact that they may take command and continue the necessary functions of the body for a time. This occurs, for example, in sleep, when the spinal cord acts without the intervention of any of the higher nervous centers, as for instance, when it withdraws a limb from contact with a stimulus. As a system of reflex centers, the spinal cord is quite analogous to that portion of the insect's nervous system which lies below the ganglion of the head.

Extension of the reflex arc concept to the higher centers.

The higher nervous centers above the cord are more elaborate organs, but they are in essential structure the same as the cord. Below the cerebrum, every organ of the nervous system may be said to consist of a combination of relatively independent cell centers and transmitting tracts. In the cerebrum the transmission to higher centers is, of course, no longer possible, and the central function of combination and redistribution of impulses appears as the exclusive function.

Structure and function of the cerebellum.

In the cerebellum the central function predominates. This can be shown by examining a section of this organ. Figure 14 shows one of the lamellæ, or folds of the cerebellum, much enlarged. It will be seen from this section that the cells lie, not in the center of the organ as in the spinal cord, but at the outer surface. Fibers enter the cerebellum in bundles from above and below, and terminate in a fine network

of fibrils about the cells which are situated on the surface. The surface, which is technically known as the cortex, is increased very greatly in extent by the folding, which can be seen in any figure representing this organ. The result of the folding is that provision is made for an enormous number of cells in a relatively small cubical space. Through the action of the cells in the cerebellar cortex, an impulse which comes into the cerebellum as a single impulse from one of the higher centers, as, for example, from the cerebrum, may be subdivided into a great number of currents so as to arouse, when distributed to the active organs, a whole system of muscles. Indeed, there is evidence that the cells of the cerebellum contribute in the way indicated to muscular coördinations in all parts of the body.

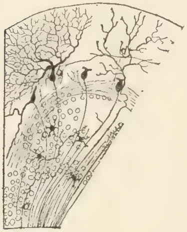


Fig. 14. A diagrammatic section through a part of one of the folds in the cerebellum. After Cajal. A fiber (*a*), entering from some other part of the central nervous system, distributes its impulse to the small cells *c* and to the larger cell *b*. From *b*, the stimulus is carried outward along the descending fiber. *d* also shows the termination of an incoming fiber. The organs here figured serve to redistribute impulses from other parts of the nervous system.

Significance of the cerebrum.

From the cord and cerebellum and the other minor centers of the nervous system, we turn to the cerebrum. Our study of the evolution of the nervous system showed the dominating importance of this organ in all of the higher animals, especially in man. The cerebrum is a complex organ to which sensory impulses come from all parts of the body and from which motor impulses are sent out to all the voluntary muscles. It is not directly connected with the surface of the body, but is indirectly the organ in control of all parts of the body. It is a central clearing house for the

organism. It is the part of the body most intimately related to consciousness.

Structure of the cerebrum.

In structure, the cerebrum consists of an external folded or convoluted layer of cells known as the cortex. This cortex is from one eighth to one twelfth of an inch in thickness and shows many variations in structure in its different parts. To these vari-

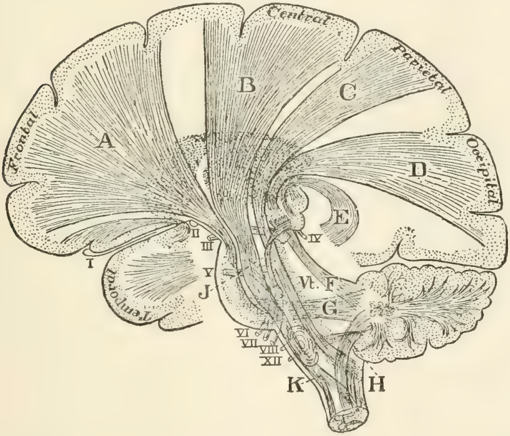


Fig. 15. A diagrammatic section of the fibers within the brain. After Starr. *A, B, C, D, E*, tracts of fibers to and from the cortex of the cerebrum connecting with the lower parts of the nervous system; *F, G, H*, groups of fibers connecting the cerebellum with other parts of the nervous system. The whole figure represents what would be seen by making a vertical section through the human brain, in the median plane perpendicular to the line connecting the two ears. Dotted areas, cortex.

ations in the structure of the cortex, further reference will be made later. The central mass of the cerebrum is composed of fibers which provide for the connection of each point of the cerebral cortex

with every other part of the nervous system. The general structure of the cerebrum may, perhaps, be comprehended most easily by referring to the systems of cerebral fibers. There are three types or systems of fibers. Figures 15, 16, and 17 represent sections

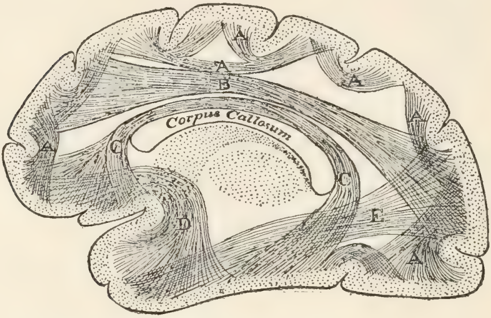


FIG. 16. Shows a lateral section through one hemisphere of the brain. The fibers represented in this figure are the association fibers connecting different parts of the cortex. From Edinger.

across the cerebrum and exhibit these various types of fibers. Large bundles of fibers (Fig. 15) connect the cerebrum with the lower parts of the nervous system. These bundles constitute, as a whole, what is known as the bundle of peduncular fibers. A second system of fibers connects the different points of the cortex of one hemisphere with other points in the same hemisphere (Fig. 16). These fibers are technically known as association fibers. The third bundle of fibers extends from one hemisphere of the cerebrum to the other hemisphere. The fibers of this group are known as the commissural fibers, and go to make up the *corpus callosum* or bridge of fibers conspicuous in any median section of the cerebrum.

Organization of impulses in the cerebrum.

No clearer evidence of the function of the cerebrum can be found than that which is given in the structure of its systems of fibers. An impulse which reaches the cells of the cerebral cortex through the sensory, or incoming fibers of the peduncular tract, is brought to the cortex for the purposes of redistribution and combination with other impulses. The elaborate system of interconnecting tracts provides for indefinite combinations and recombinations. We shall refer in all of our later discussions to the organization of nervous processes which goes on in the cerebrum. The term organization, so used, refers to the fact that a nervous impulse, when it reaches the cerebrum, is united with other impulses and is carried along complex series of paths, until finally it is discharged into the motor channels which pass outward to the muscles. No impulse which reaches the cerebrum can escape combination with other impulses; the purpose of the whole structure is to provide channels for the most complete interconnections.

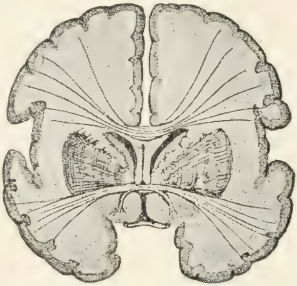
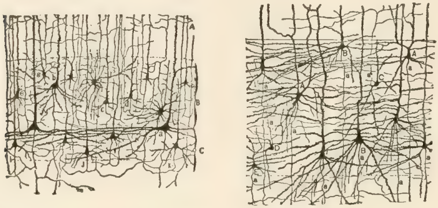


Fig. 17. A transverse section across the two hemispheres in a plane passing vertically through the cheek bones parallel to a line connecting the two ears. This section shows the fibers which establish communication between the two hemispheres. When the fibers in this figure are supplemented by those represented in the two preceding figures, it will be seen that every point on the cortex of the cerebrum is in communication with all other parts of the nervous system. From Edinger.

Cerebral cortex.

The cortex of the cerebrum has a structure of such complexity that it has been impossible, until very recently, to define with anything like certainty its

various parts. Figures 18 and 19 represent two typically different areas, while Fig. 20 shows a diagrammatic representation of some of the different elements which are characteristic of the cerebrum. Though we are ignorant of many of the details of cortical structure, we are well informed as to the functions of large areas of the cortex. The cortex may be divided into three kinds of areas or centers; these are sensory areas, motor areas, and association areas. The sensory



Figs. 18 and 19. These figures represent portions of the cerebral cortex from two areas of the human brain. Figure 18 shows the sixth and seventh layers from the visual cortex. The horizontal distribution of the dendrites of the large pyramidal cells is characteristic of this region. In Fig. 19 the giant pyramidal cells from the motor area of the cortex are exhibited. The dendrites, it will be observed, are of an entirely different character from those shown in Fig. 18. Furthermore, the size and number of the large pyramidal cells are very different in the two cases. From Cajal.

areas are those which have the most direct relations to the various organs of sense; the motor areas are those which stand in most direct relations to the active organs. There is no part of the cerebrum which has simple and immediate relations to the surface of the body, so that the terms sensory and motor are merely relative terms, the sensory centers being those points at which the stimulations from the organs of sense are first received in the cerebrum, the motor areas being those points from which the stimulations pass out of the cerebrum on their way to

the muscles. The association areas, as the name indicates, are areas of a still more indirect character, in which sensory impulses, after being received in the sensory areas, are recombined and redistributed. In a very proper sense of the term, all cerebral areas are associative areas, for they all serve the function of indirect combination and distribution of nervous impulses. Those which are specifically designated as associative, have claim to the specific name, because they perform a function of even higher combination than do the others. Figures 21 and 22 show the centers of these types which appear on the surfaces of the human cerebrum.

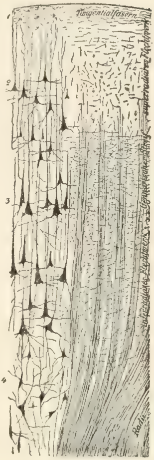


FIG. 20. A diagrammatic section showing the structure of the cortex of the cerebrum. On the left-hand side of the figure, the cells alone are shown. On the right-hand side of the figure, the fiber systems alone are indicated. The figure does not represent adequately the complexity of the structure. Many small cells are not here represented. A general impression, however, can be gained from the figure of the complexity of the cortex. After Edinger.

Methods of discovering cerebral localization. First, stimulation.

It may be interesting to digress for a moment from the structure of the cortical centers to the discussion of the method by which these centers have been located. A great number of experiments have been tried on the higher animals. Certain of the areas have been artificially stimulated, and when muscles in different parts of the body have responded promptly and regularly to these stimulations, the connection between the areas stimulated and the muscles thrown into action has been recorded. Evidently, artificial stimulations of this kind would be of little value in locating sensory or association areas, for there are no clearly marked mus-

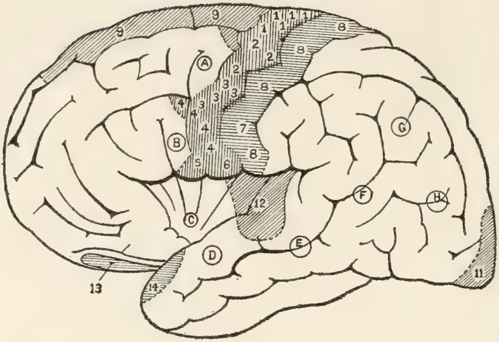


Fig. 21. The outline of the lateral surface of the cerebrum with the typical convolutions, as given by Flechsig. The shaded portions indicating the sensory and motor centers, and the small circles indicating certain well-defined association areas, are given according to Tschermak in Nagel's *Handbuch der Physiologie des Menschen.* Vertical lines in the shaded areas indicate motor areas, horizontal lines indicate sensory areas, oblique lines indicate sensory-motor areas. *1, 1, 1, 1, 1* are the motor areas for the toes and foot; *2, 2, 2* are the motor areas for the shoulder, elbow, and wrist; *3, 3, 3, 3* are the areas for the fingers and thumbs; *4, 4, 4, 4* are the motor areas for the eye and other parts of the face; *5* is the center for the vocal cords; *6*, for the tongue; *7* is the sensory area for the head; *8, 8, 8, 8* are the sensory areas for the regions to which motor stimulations are distributed by the areas *1–6; 9, 9* are the sensory-motor areas of the trunk; *11*, visual area and occipital area for the eye movements; *12*, auditory area and temporal center for visual fixation; *13*, olfactory bulb; *14*, probably olfactory area. The area where vertical and horizontal lines cross between the motor areas *1–6*, and the sensory areas *7, 8*, is probably connected with the muscle sense. *A*, motor writing center; *B*, Broca's motor speech center; *C*, probably memory-motor speech center; *D*, sensory music center; *E*, Wernicke's sensory speech center; *F*, memory-sensory speech center; *G*, memory reading center; *H*, sensory reading center. All of these lettered areas are associational centers.

cular effects when the stimulus is applied to areas other than those directly related to the muscles. For ex-

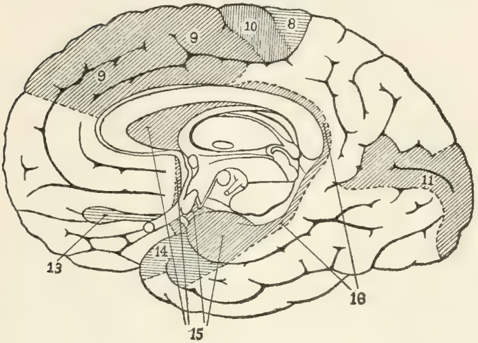


FIG. 22. Represents the median surface of the human cerebrum and shows, as in Fig. 21, the various areas. *8*, sensory area for the lower extremities; *9, 9*, sensory-motor areas for the trunk; *10*, motor area of the lower extremities; *11*, visual area and occipital motor area for visual fixation; *13*, olfactory bulb; *14*, probably olfactory area; *15, 15, 15, 15*, olfactory areas; *16, 16*, probably gustatory areas. For reference to authorities for this figure, *see* Fig. 21.

ample, the stimulation of the visual center would show only the motor effects of such stimulation and would not give any clear indication of the sensory character of the area.

Extirpation and comparison of pathological cases.

A second type of experiments which have been productive of results depends upon extirpation of the tissues. Certain areas of the cerebral cortex of animals are cut or burned out, and the loss in function resulting from this removal of the nervous tissue is carefully studied. This method can be used in the locating of both sensory and motor centers. There are cases of disease of the human nervous system analogous to these cases of extirpation in animals, and careful study of the loss of human functions shows that the human cortex is subdivided in much the same way as that of the higher mammals.

Embryological methods.

There are other methods of investigating cerebral areas which deal with the internal structures. One of the most productive of these methods depends upon the fact that the different areas of the cerebrum do not develop at exactly the same period in the embryological or infant life of a human being. The human embryo exhibits in its early stages a development of the nervous system about the central fold or fissure, known as the fissure of Rolando. This area of earliest development is in the region marked in Fig. 21 as the motor area and the area of tactual sensitivity. Later, the nervous system matures in the remaining sensory centers in such sequence that it is possible, by the study of the microscopic anatomy, to secure a fairly complete chronological account of the development of the different regions. The association areas are the latest to develop. Indeed, in the association areas the development can be traced for a period after birth, and indirect evidence seems to make it clear that the development goes forward well on into mature life.

The association area in the parietal lobe.

The visual area in the occipital region, as indicated in Figs. 21 and 22, is the area through which impulses resulting from retinal stimulation are first introduced into the cerebrum. A similar area for the reception of auditory impulses appears, as indicated in the figure, just below the Sylvian Fissure. Without entering further into a discussion of the various centers, it will be enough to call attention to the relation between the visual and auditory areas and the association area lying between them. The association area in question, known as the parietal association area, has developed in the course of the evolution of the cerebrum between the visual and the auditory centers as the area in which the stimulations from these two centers may be brought together and combined. There are many evidences that the combinations of visual and auditory impulses do, as a matter of fact, go on in the parietal association center. For example, there is in this parietal region one area which is of extreme importance in the function of speech. If this area is disturbed, the individual may remain quite capable of receiving visual impressions through his

eyes and of receiving auditory impressions through his ears. He may even be capable of articulation, which is a motor function, but he will lack the ability to interpret the impressions which he receives when he hears or sees words or to give expression to a coherent series of ideas. The area in question has, therefore, been designated as the ideational area. It is ideational rather than sensory, because it is the seat of a series of functions more elaborate than those which are involved in the mere reception of impressions. It is the center for the combination of visual or auditory impressions. More than this, the association area is, undoubtedly, a center which becomes more and more highly organized through use, so that the influence of the area upon any present impulses is, doubtless, such that we are justified in saying that it adds to these impulses the effects of past experience. In an important sense, it associates present impressions with past impressions, as well as combines present impressions from different senses. It thus serves in a large way the function of a reorganizing center for visual and auditory impressions.

Significance of the central position of the general motor area.

Another important fact, which will be observed immediately on inspection of Figs. 21 and 22, is that the general motor area occupies a relatively central position in the cerebrum. The area of touch and of general sensibility seems to offer an exception to the general rule of distribution of sensory and association centers around the motor area. This sensory area is not separated from the motor area by an association area, as are the other sensory centers. We see in this relation of the cerebral centers for touch and movement the structural fact which corresponds to the functional fact that the skin and other tissues which give rise to tactual sensations would naturally, as the earliest organs, stand in so intimate a relation to the muscles that the later, more highly developed organs of sense, could not be expected to duplicate this relation. As the primitive tactual sensory surfaces came to be supplemented by newer and more highly specialized organs of sense, the nervous centers for the newer senses were

forced to take up more remote and complex relations to the motor area, while the original senses did not lose the intimate relation which they bore from the first. The development of the higher senses furnished also opportunity for greater variety in the combination of sensory impulses, consequently the associative functions and areas increased with the development of variety in the sensory functions. The association centers, which are the structural areas given up to the functions of working over sensory impulses, naturally developed between the centers which performed functions of reception, or the sensory functions, and those which performed the functions of motor discharge. The topography of the cerebral centers thus reflects directly the gradual evolution of more and more elaborate systems of nervous organizations.

The speech center and aphasia.

Another group of facts which will serve to make clear the character of the association areas is to be found by examining that portion of the cerebrum which is known as the speech area. This region of the brain was first recognized by the anthropologist Broca as intimately related to the functions of speech. He found that disease in this area resulted in impairment of the patient's ability to use or understand language. Later studies of aphasia, as the pathological loss of speech is called, have increased our knowledge of this area, especially since it has become possible through the examination of a large number of cases to distinguish a variety of forms of partial aphasia. Thus, a person may be able to understand words which he hears, but be quite unable to understand words which he sees on a printed page. This form of so-called visual aphasia is paralleled by forms of auditory aphasia, in which the subject is able to read, but cannot understand words which he hears spoken. These two forms of partial aphasia indicate that the connection between the speech center and the visual center may be interrupted without destroying the connection between the speech center and the auditory center. If the disease of the speech center is strictly localized so as to interrupt only its connection with the visual center, the

other functions may remain intact, while the visual forms of recognition of language are interrupted. Turning now to the various forms of motor aphasia as distinguished from the forms of sensory aphasia mentioned, we have equally clear evidence of the nature of the association center. An individual may lose the power of articulation without losing the ability to write, or he may lose the ability to write without losing the ability to articulate. In either one of these forms of motor aphasia, the subject may be comparatively free from sensory deficiencies. The lack of ability to articulate, when all of the other phases of the function of speech are present, shows that the connection with the visual and auditory centers may be complete, as well as the connection with the motor area for the hand movement involved in writing, while the motor connection with the center which sends impulses to the muscles of the vocal cords may be temporarily or permanently interrupted.

Broca's convolution, an association center.

Broca's convolution thus turns out to be an association area in which a great variety of lines of connection converge. It is not a part of the nervous system which acts independently in the control of a separate faculty of speech; it gains its significance in the individual's life by virtue of the control which it acquires as a center for the organization of stimulations received in other parts of the cortex and carried through the cells and fibers in this area in process of transmission to the motor area.

Phrenology not in accord with clearly known facts.

It may be well to call attention at this point to the fundamental distinction between the teachings of phrenology and the discoveries of modern brain physiology. Phrenology maintained that different parts of the brain are given over to different faculties. For example, phrenology believed in a certain area for the recognition of form, another area for the recognition of number, an area for the function of parental love, and one for the general trait of combativeness. There is no justification for a theory of localization based upon a subdivision of consciousness into such mythological faculties. The cortical area can be subdivided along

the lines of sensory impulses and motor impulses and their organization in association areas. Conscious processes must be considered as having their physiological conditions, not in separate points assigned to imaginary faculties, but rather in the organized activity of sensory, motor, and association areas. For example, the recognition of form naturally includes certain sensory functions and certain associative processes. The general neural basis for such sensory and associative processes we know, as has been shown in the foregoing paragraphs. To be sure, we do not know at the present time all the details of the cerebral map, but the broader outlines are too clearly defined to leave any room for mistaken notions with regard to the kind of functions which are provided for in the different areas of the cerebrum.

Frontal association area.

One area of the cerebrum which has been the subject of much speculative discussion is the frontal area, or that portion of the cerebrum which lies in front of the motor area. In certain cases large portions of this area have been destroyed without apparent interference with the individual's normal functions. There is a famous case known as the American Crowbar Case, in which a common laborer, through an accident in blasting, had a very large portion of this frontal lobe removed by a crowbar passing through the roof of his mouth and out through the top of his skull. The individual in question continued to live with no serious interruption of his regular nervous or physical functions. Such cases as this may possibly indicate that the association areas are not fully developed in some individuals. In general, it is doubtless true that association areas, more than other parts of the nervous system, are left open for development through individual experience. If this conception is accepted, it is not surprising that an individual might be deprived of the possibility of further development, or even of some of his higher forms of association without the loss being obvious to himself or to those who observe him. Recent experiments, which have been tried in the extirpation of the small frontal area in cats and monkeys,

show clearly that the frontal area is the part of the nervous system involved in newly acquired habits. The fact that man, who alone of all the animals has a large frontal lobe, is the learning animal *par excellence*, further confirms the general view derived from these experiments.

The function of the nervous system is the organization of sensory impulses.

The foregoing brief description of the human nervous system has omitted many of the details of organization in the hope of leaving a general impression of the complexity and intimacy of the relations which exist between the parts of this system. Everywhere there are paths for the reception, combination, and discharge of impulses received from external stimuli. The nervous system transforms sensory impulses into motor impulses. It does much more than this. It transforms sensory impulses from all parts of the surface of the body into harmonious, associated impulses, and then it distributes these associated impulses to the various muscles of the body in coördinated systems of motor discharge which result in effective movements of the muscles. The system of organizing centers is so highly developed that in the cerebrum, regions are set apart for the purpose of reorganization and redistribution. It is in connection with this highest type of reorganization that consciousness appears.

The objective conditions of consciousness, emphasized in science.

This last statement regarding the relation of consciousness and cerebral activity brings us to the threshold of our psychological problem. Our approach to the problem of consciousness has been of set purpose, indirect and objective. The ordinary man is first aware of his conscious experiences and only very remotely aware of his nervous system. It is for this reason that man has been disposed to treat his conscious life as a reality apart from other realities. Consciousness is, indeed, the only reality open to direct introspective observation. When, on the other hand, the student approaches consciousness from the objective side and notes how the higher nervous organizations are gradually evolved from a long series of lower forms, he is sometimes baffled to find in the evolutionary scheme any place for consciousness. The active processes

of animals develop in successive degrees of complexity from the reflex movements of the lowest animals provided for in the lowest forms of the nervous system, up to the most elaborate purposive movements of an intelligent man. It seems easy to adopt a purely mechanical explanation for the lower processes and to pass from this mechanical explanation of reflexes without interruption to a mechanical explanation of the most complex forms of behavior. The presence of consciousness is more or less of an embarrassment to one who takes this view of behavior, for it tends to delay the easy progress of his explanation from the point of reception of the stimulation to its point of motor discharge. The result is that the student of the human nervous system often disregards consciousness and looks upon the neural series as complete without reference to experience, or at most he admits the experience series as a parallel but inefficient train of processes.

Evolution results in individuation.

The student of psychology cannot overlook the relation of consciousness to neural processes as does the ordinary observer, nor can he be satisfied to ignore consciousness, as is sometimes done in science. He must consider the facts with a view to both the objective and subjective demands. It seems to be true that the lower animals have little conscious experience; their nervous structures are very dependent on external forces which initiate and control action to such an extent that the whole life of the animal is controlled directly by the external excitations which act upon its organs of sense. As we ascend the scale, the function of neural transmission is supplemented in ever increasing degree by the function of internal organization. The significance of this internal organization may be expressed by the statement that the animal becomes more and more organized and individuated. When a stimulus acts upon a highly individuated animal, the effect of the stimulus sooner or later comes back into the outer world in the form of a muscular movement, but the form of muscular contraction is determined in relatively large measure by the internal structure of the animal and only in a small degree by the external stimulus.

What has been said about individuation has its most complete exemplification in those highest animals which are possessed of cerebral centers for the indirect associative organization of sensory impulses. In man, for example, the path of transmission from sensory impulses to the muscles is so long and devious that the path is incomparably more important than the impulse which travels along it. In fact, transmission is here swallowed up in a process of organization so elaborate and complete that any scientific study of man will be obliged to lay its greatest emphasis on the organs and processes of association and fusion, not neglecting, to be sure, the organs of reception, transmission, and movement, but regarding them all as subservient to the higher forms of organized central activity.

Consciousness is inseparably related to organization of nervous processes, but constitutes a unique fact which must be recognized.

With the evolution of higher forms of internal organization, there has come into the world a unique system of facts which we designate as the facts of individual experience. These individual experiences depend upon all the conditions which surround individual life, but they are more than these conditions. The analogy which helps us in understanding this statement is the analogy of life in general. There are certain physical and chemical agencies necessary to the development of life, but life must be treated as a unique combination of these agencies. The recognition of the fact that organization of living matter is more significant for the understanding of life than is the enumeration of the elements which are brought together in this organization, does not for a moment ignore the elements which constitute the living organism, but does call attention to the unique product of their organization. Similarly with conscious experience, it cannot be regarded as standing alone, explicable without reference to the sensory and motor processes, or without reference to the processes of nervous organization with which it appears to develop in the animal world. Experience is, however, a unique fact. When one has described the nervous organization of an animal, he must say that this organization is the condition of experience, but it is not identical with experience. Experience is, like life,

related to organized physiological structures; it is, however, a body of processes constituting a world of reality which cannot be either overlooked or subordinated to the conditions of organization which make it possible. Indeed, experience has a type of reality which justifies the assertion that it is the primary reality. For the individual, the world of experience is so essentially the center of his unity and of his existence that all of his other attributes, such as physical organs, even though they are related to experience, are seen only indirectly through experience. Thus, when we wish to know the nervous conditions of our experience, we are obliged to study ourselves through experience and to arrive by a series of indirect observations and inferences at a full knowledge of all these conditions.

Consciousness is no less real than its conditions.

The physiological conditions of experience do not lose reality because they can be studied only through experience itself, neither does experience lose its reality because its conditions are known. The difficulty in the whole situation is that the individual who is trying to explain and understand himself sometimes loses sight of the central fact of his own mental life, as he explores the conditions which surround this central personality. The central personality is taken so much for granted that scientific description tends to deal with all that leads up to personality, and there it stops, finding its chief subjects of thought in these surrounding facts, rather than in the central result of all the organized conditions. Some day the historian of thought will write it down as one of the curious fallacies of immature science that certain physiologists, biologists, and even psychologists, were satisfied to call their own personalities mere by-products, without essential significance in the world, just because they did not find consciousness capable of description in the regular scientific formulas adopted for the discussion and explanation of external reality. One hardly knows how to find phrases in which to answer those who hold consciousness to be less real and potent than physical forces. Certainly, nature has protected and conserved

consciousness throughout the whole development of the animal kingdom. Certainly, the world is different because consciousness has been evolved. Certainly, consciousness is no less real than are its conditions; and, finally, consciousness is certainly much more directly approachable to the student of science than is matter.

Consciousness the special problem of psychology.

The proper course for the psychologist is clear before him. He should not ignore the conditions of mental life whenever he can find them, nor should he ignore the unique reality of consciousness. It is the laws of consciousness which he is to investigate, securing all the light he can upon his problem by a study of physiological conditions, but recognizing in mental life a series of facts distinct from any of the physiological processes which condition consciousness. If he finds in the study of the nervous system evidence that consciousness is a system of highly organized processes, let him utilize this discovery in tracing out the details of conscious life. If he finds evidence that consciousness is conditioned by sensory processes and by the demand made upon the individual for organized motor reactions, let him again utilize these evidences in gaining a clear view of the nature of particular conscious processes. On the other hand, when he comes to explain the reaction of an individual upon his environment, let him recognize the fact that reaction preceded by conscious deliberation is more complex and more indirect than reflex action or any of the forms of action which can appropriately be described as purely mechanical in character.

The attitude of psychology toward consciousness.

It will be the purpose of subsequent studies to carry out in detail the outline here given of the proper course for psychology to follow. Consciousness will be studied in its special forms and in its unity as constituting a centralized individuality. The conditions of consciousness will constantly be kept in mind. Finally, the relation of conscious organization to individual life and adaptation will be studied. There will be no effort to treat consciousness as a reality apart from its conditions, nor will there be any effort to ignore the existence of consciousness as a unique fact in the world

CHAPTER IV

GENERAL ANALYSIS OF CONSCIOUSNESS

Necessity of analysis.

Up to this point in our discussion, the references to consciousness have been in general terms. No account has been taken of the fact that there are a great variety of different forms of mental activity. This treatment of consciousness as a general fact was legitimate, so long as our problem was the definition of the broad relations of consciousness to the other aspects of life. A complete account of consciousness means, however, much more than has been involved in these general discussions. The various forms of mental activity must be examined in detail, their special conditions and characteristics must be investigated, and their relations to each other must be fully defined. It is only by thus studying all phases of experience that a full explanation of conscious life is to be worked out.

Contrast between scientific and unscientific analysis.

There are a great variety of ways in which the facts of mental life may be classified. The ordinary thinker who is not interested in the conditions of consciousness, but is interested in giving some practical description of his inner moods and intellectual achievements, uses freely such distinctions as pleasure and pain, ideas and fanciful imaginations, resolutions and decisions. When we take up the scientific study of consciousness these popular distinctions constitute at once a series of valuable suggestions and a source of confusion. An analogy will help us to understand why a popular classification of facts very often serves badly the purposes of science. If an untrained observer were asked to describe the different parts of the body, he would naturally begin by distinguishing certain of the gross parts of the body. He would speak of arms and legs, of face and back, and other parts which are very obvious

or are of special practical interest. Science finds, however, that the distinction between the organs of the body must follow other lines. Instead of treating the arms and legs as fundamental subdivisions of the bodily structure, science emphasizes the distinction between muscles and bones. The face is recognized as by no means a unitary structure; it is made up of organs of sense, of mastication, of respiration, and so on. In much the same way, popular distinctions of the different phases of experience must be revised before they can be used by science. A striking illustration of this is to be seen in the fact that in popular thought pleasure and pain are usually treated as facts of the same order, though contrasted in quality. A moment's consideration will make it clear that pain ordinarily arises from some definite point in the body. It is a type of experience which we classify in science along with those experiences which come from the stimulations of the skin or the inner surfaces of the body and are technically known as sensations. Pleasure, on the other hand, has a totally different type of origin. It is not a phase of sensation; it does not come from particular points of stimulation. It must be treated as a type of experience which grows out of general organic excitations of a much more central character than those which are involved in the production of pain. Again, such a term as attention, which has a large practical use in ordinary life, is one of the most confusing terms when it is carried over into scientific study. If one recognizes, as he must in psychology, that attention is capable of a great variety of different degrees, he will find it possible to extend this term over every possible experience. There are forms of intense and vivid consciousness for which some term, such as vividness or attention, is undoubtedly required in science. There are other forms of consciousness which are relatively vague and indistinct, yet when dealing with these cases we cannot fail to recognize the necessity of using the word "attention" or some such phrase as "low degree of attention," if we have adopted the word into our scientific vocabulary.

The distinction between attention and consciousness as a whole is therefore difficult to define. These illustrations will make clear the problem which confronts psychology when the attempt is made to secure an analysis which is at once satisfactory for purposes of scientific treatment and explanation, and in keeping with ordinary introspective observations.

The historical threefold system of classification.

In the history of psychology, many efforts have been made to develop an appropriate scientific classification of mental processes. One of the classifications which was for a long time generally accepted is that which grouped all forms of experience under the three general heads of knowledge, feeling, and volition. There can be no doubt that such a threefold classification describes certain fundamental differences in conscious experience. The man who is engaged in thinking out some problem of science is certainly not at that moment absorbed in an intense feeling or emotion. On the other hand, the man who is thoroughly angry over some situation which has arisen, is by no means in a condition to consider logically and judiciously the facts which appeal to his thoughtful neighbor who is free from emotional excitement. It is somewhat more difficult to justify the classification of volition as different from knowledge and feeling, for no serious thought is possible without some voluntary effort, and no emotion ever arises without inducing some form of action. Yet, even though volition is intimately interwoven in all forms of knowledge and feeling, there are certain cases of decision which are not to be regarded as typical processes of knowing, or processes of feeling; hence, the term volition is needed for a full description of mental activities.

Twofold classification.

Another somewhat different type of classification has been used by certain writers; according to this, only two different types of experience are distinguished, namely, knowledge on the one hand, and active processes on the other. This twofold classification offers less difficulty to explanatory science than the threefold classification, because it is more general. In bringing together a great variety of facts under the active

processes so-called, we are freed from the necessity of making any sharp distinction between the feelings, which are undoubtedly active aspects of consciousness, and decisions, which from any point of view must be regarded as active.

Criticism of the earlier types of analysis.

The general difficulty with the threefold classification and also with the twofold, is that they are by no means detailed enough to serve as the basis for the discussion of the different varieties of consciousness. This appears at once in the fact that knowledge must be subdivided into a variety of forms, and when this subdivision is made, we find that our minor subdivisions conflict with the major subdivisions with which we started. For example, whenever one distinguishes as forms of knowing the two processes of comparison and discrimination, he finds it extremely difficult to justify his classification of forms of knowledge without reference to activity. Again, it is not easy to find in the threefold or twofold classifications a suitable place for the general function of memory. In habits we give expression to forms of behavior which have been brought over from past experience, while in the incidental recollection of some earlier experience we may seem to be almost entirely passive, dependent on the chance revival of an impression which is now received as a simple fact of cognitive experience.

Science should classify on the basis of conditions as well as introspections.

The difficulties in securing a suitable classification of mental processes for the purpose of scientific study have been discussed in some detail for the purpose of preparing the student for a departure from the lines of division which he would naturally be disposed to suggest on the basis of his earlier unscientific introspections. We shall hold once more to the objective conditions of consciousness and shall accept as a distinct group of facts any which are differently conditioned and, at the same time, different in their subjective characteristics and relations. When this principle of classification is adopted, it will be found to include all of the essential distinctions which have been suggested by those who have taken up the study of consciousness in purely introspective terms, and it will, furthermore, facilitate the

study of the conditions of the different aspects of conscious experience.

Sensations.

One of the most fundamental facts of experience is that conscious impressions are continually being received from the outer world. These impressions we call sensations. Red, green, a sound, an odor, a taste, a pressure against the skin, are typical sensations. This first class of experiences is directly related to certain well-known processes in the nervous system. Nervous processes originate in the organs of sense and are transmitted to the central nervous system. On both the objective and subjective sides, therefore, we are justified in distinguishing sensations as a fundamental group of processes.

Relations between sensations, perceptual relations.

Sensations, however, are not the whole of conscious experience. We have the most elaborate relations developed in the course of experience between the different sensory phases of consciousness. Without going into any great detail, we may illustrate this fact by the statement that one cannot have a sensation red and a sensation green in his consciousness at the same moment without recognizing the contrast between these two colors. What is true of color comparisons is true also of a great variety of other forms of comparison and contrast. For example, every object stands out in space from its background. There is also a transition in time and in type of consciousness from one experience to that which follows it; this is either abrupt or gradual, — in either case the character of the new experience depends in part upon its relation to that which preceded it. These illustrations justify the general statement that conscious processes are made up not only of sensation factors, but also of relations between these sensation factors. Such relational processes give rise to forms of experience designated as percepts. The relations which give rise to percepts are known as perceptual relations.

Attitudes.

In the third place, we find as we study consciousness that there are certain modes of reaction to our sensory experiences. As observed introspectively, these reactions are seen in the different attitudes which we

assume toward our impressions. One is pleased with a certain color, or he is displeased. Such an attitude toward a color is by no means to be explained in the same terms as the color sensation itself. We must, therefore, seek some formula for the attitudes of mental life which shall recognize the distinction between these attitudes and the sensations to which they are applied.

Physiological conditions of relational processes and attitudes.

As in the case of sensations, so also in dealing with relations and attitudes, we have physiological processes which parallel and condition these complex phases of conscious experiences. Relational combinations conditioning the relational forms of consciousness are continually going on in the nervous system, especially in the cerebrum; and motor processes are always present as the ends of nervous activities and as the conditions of mental attitudes.

Memory factors.

The classification, as outlined up to this point, provides for only one type of content or subject-matter of experience; namely, sensation. Relations and attitudes are not content; they are modes of treating sensations in consciousness. It is, however, universally recognized that this is not an adequate statement to cover all phases of experience. When one looks into his consciousness at any moment, he finds much content or subject-matter of thought which does not come through present sensation. There is content derived from memory as well as from the present environment. It is not easy to meet the demand for a recognition of memory by simply adding a fourth class of memory factors to our three forms of conscious activity already described, because memory contributes to present consciousness not merely content factors, but also dispositions to organize the contents of consciousness in certain familiar relations, and also dispositions to assume certain familiar attitudes. In other words, memory may bring into present experience any phase of earlier experience. If we speak of memory factors, therefore, we must recognize that the term factors is much broader than the same term when used with reference to sensory experiences. With this definition of the

term, we shall accept as our fourth group of facts, the memory factors.

Organic memory.

Here again, we have ample ground for applying to the physiological conditions of experience the distinction between retained or memory processes and direct sensory processes. This matter has not come up in our earlier discussion, but it is a familiar fact that organic tissue of every form retains the effects of earlier excitations. This is preëminently true of the highly organized nervous tissue.

Higher relational processes.

A fifth class of conscious processes grows out of the interrelation of the various factors and processes included under the fourfold classification thus far outlined. The significance of this statement may, perhaps, be made clear by an example. When one uses a word with intelligent recognition of its meaning, his experience is a complex of direct sensory factors, of relations between these sensory factors and elaborate memory processes. Thus, one hears the sound of the word which he localizes as coming from a certain speaker, or as differing in quality from other sounds. He has also a series of memory images or some other contributions from his past experience. One may have an attitude toward the sound which may be called the primary or sensory attitude, depending on the harshness or loudness of the sound. But above all these direct and memory factors stands the meaning which the word acquires through the combination of all these elements. This meaning is a derived interpretation, not dependent alone on sensation or memory or localization, but rather upon the most elaborate organization of all the phases of consciousness connected with the sound.

Ideational relations.

We must leave it for later discussions to justify more fully the enlargement of our classification to include as a fifth type of conscious process that suggested in the illustration and to be designated as indirect or ideational relation. This fifth class is to be regarded as distinct from memory; its indirectness is due to its complexity, and not primarily to its inclusion of memory factors.

Ideational relations and associational processes in the cerebrum.

The physiological parallel for these ideational relations is undoubtedly to be found in the fact which has been so fully emphasized in earlier chapters; namely, the fact that the cerebrum shows in its whole development and organization the great significance of indirect modes of organization. The processes in the associational areas of the cerebrum get their significance, not from the sensory or memory factors which arouse them to action, nor yet from the simple relations between sensory processes, but rather from the fact that they organize in the highest and most elaborate processes all of the simpler elementary processes.

Bodily action as a supplementary topic.

It may be well to mention in this discussion of the special subjects to be taken up in psychology two supplementary topics which naturally follow upon the discussions provided for in the foregoing classification. The first of these supplementary discussions concerns itself with the final outcome of all conscious and nervous activity, which is bodily movement. In some form or other, every incoming sensory impulse and every central nervous process must issue in a motor discharge. It is equally true, though by no means so obvious, that every form of conscious experience is related to behavior. The effort of psychology in its earlier forms to distinguish between cognition and volition was a failure, as has been pointed out, because there is no form of cognition which does not involve also volition. If we do not treat the distinction between volition and knowledge as a fundamental distinction, but merely recognize the fact that volition is the end toward which all conscious processes tend, we are justified in considering these ends toward which conscious processes tend as a separate topic worthy of special attention. We can consider the different modes of issue of conscious processes, and in this way reach a distinction between different types of behavior. With this recognition of the character of the distinction between different types of behavior, we shall in our later treatment devote some consideration to the matter.

A final topic for our consideration arises from the fact that there exist in human experience certain

Abnormalities in consciousness in contrast to normal organizations.

abnormal forms of organization, which abnormal forms of organization are of special practical interest and require an explanation that does not grow directly out of the treatment of normal processes. Here again, we deal not with a major distinction in our subject-matter, but rather with a practical corollary of the main discussion.

Summary.

The following brief summary of the foregoing discussion will serve as a guide to the later treatment: —

I. SENSATION FACTORS.
   This includes the description of the organs of sense and conscious processes aroused by the action of external stimuli on these organs.

II. RELATIONS BETWEEN SENSATIONS.
   These are sometimes called forms of perceptual fusion.

III. ATTITUDES.
   These correspond to a variety of popular concepts, especially to what has been designated in psychology as feeling, interest, attention.

IV. MEMORY CONTRIBUTIONS TO EXPERIENCE.
   These are of a great variety of types, including memory images of sensations and sensory relations and attitudes.

V. IDEATIONAL RELATIONS.
   These constitute the characteristic forms of human consciousness and include such facts as experiences of language and forms of scientific thought.

SUPPLEMENTARY TOPICS.
   A. — Forms of behavior.
   B. — Abnormalities in conscious and nervous organization.

CHAPTER V

SENSATIONS

Sensations not copies of external forces.

For the ordinary man there is no problem for psychology presented by a sensation. A sensation is for his thinking an inner reflection or copy of an external fact. He dismisses as curious speculation any statement which would tend to impair his confidence in the directness of the relation between sensations and external or objective facts. Yet, as was pointed out in an earlier paragraph, the progress of science has forced upon us a distinction between objective colors and sounds, on the one hand, and subjective or experienced sensations of color and sound, on the other hand. For example, color as we see it in our individual experiences is not a form of vibration, while color as the physicist finds that he must describe it in order to explain its physical nature, is a form of wave motion easily convertible into other wave motions, such as those of heat, which in turn give us sensations of a sort quite different from colors.

Laws of sensation as one of the first problems in psychology.

The moment we admit a distinction between subjective color and external light vibrations, certain important scientific questions immediately suggest themselves. Thus, we are led to inquire what are the laws of subjective color as distinguished from the physical laws of objective light? For example, in passing from one color in the subjective series to the next color, is the transition of the same type as in the objective series, or is it different? Again, in regard to the function of subjective color, we may ask what ends as stimuli to behavior do subjective colors serve which objective light vibrations could not serve? These and like questions regarding sounds and tastes and odors constitute one of the large spheres of psychological inquiry.

Sensations classified according to the organs of sense.

The relation of sense experience to the several forms of physical energy is not the only question which science has brought to the attention of psychology. Physiology, and even popular thought, early recognized the relation between experience and the organs of sense. To take a striking illustration, it is because we have an organ of sense which is affected by light and no special organ affected by weak currents of electricity, that men overlooked for so long a period both the prevalence of forms of electrical energy and the close relation between light and electricity. Such an illustration calls attention to the fact that experience differs in certain of its aspects from the physical world, because experience is related to the physical world only indirectly, through the organs of sense. The first classification of impressions which suggests itself and the one which has become traditional, follows the enumeration of the organs of sense. There is no reason why we should not accept this general classification as a basis for psychological study.

The order of study may be genetic, or may begin with the highest types.

It is a debatable question which group of impressions should be studied first. Certain of the systems of sensory experience are relatively simple, as, for example, those of touch and taste. They represent the levels of sense in which human beings and the higher animals are most closely related to the lower animals. If we should begin with these, our progressive studies would fall into a natural evolutionary series. If, on the other hand, we begin with one of the higher forms of sensation, we shall find much greater complexity and many refinements which are so typically different from those in the lower animals, that it will require much caution to carry our generalizations back and apply them to the undeveloped types of sensation. We shall, however, have the advantage of knowing from the first a complete and elaborate series of sensory processes. Without overlooking the advantages of pursuing a strictly evolutionary order, we have chosen in the following exposition the inverse order, and will begin with one of the two most highly developed of the sensory series; namely, the series of visual sensations.

A. *Visual Sensations*

Visual sensations can be described only to a person who has experienced them. Red and blue and yellow and black are names of visual sensations. If the reader has had experiences corresponding to these words, he will also recognize that each of the experiences referred to is a unique fact in his mental life. Red may be like orange or yellow; it may be soft and pleasing, or glaring and unpleasant; but its essence is its redness, and this essence which is called the quality of the sensation can be illustrated, but cannot be defined in terms of any other experience.

Visual sensations as ultimate qualities in experience.

If we consider all possible visual sensations, we notice at once that there are two general groups, — those which belong in the series of colors and those which belong in the black-gray-white series. The latter series is in some respects the simpler. Beginning with the darkest black, one may arrange various shades of gray in an unbroken series up to the brightest white. The color series is more complex. It is made up of sensation qualities which, to be sure, shade into each other through intermediate colors; but the members of the series have a marked individuality which leads us to designate them by a variety of entirely different names rather than by a common term, such as is used in referring to the gray series. Thus, red and yellow are different qualities, though they shade into each other through orange; when we pass from one to the other, the transition is so marked that we are compelled to describe red and yellow as different qualities.

Chromatic or color series, and achromatic or gray series.

The question of how many fundamental visual qualities there are, is one that has often been discussed. Popular language has clearly marked out at least four color qualities besides the blacks, grays, and whites. These four colors are red, yellow, green, and blue. The names of these colors are, as their form clearly indicates, older than such derived names as orange, indigo, violet, or any of the compound names, such as green-blue and yellow-green. The loose use of the four older

Fundamental color names.

color names makes it clear, however, that there is no particular red or green which can be treated as distinctively primary. In making up a system of color terminology for such works of reference as a dictionary, this fact comes out very clearly. The best that can be done is to take the average of a large number of usages and exhibit a sample of the color chosen. Color names, therefore, while suggesting something of the popular discrimination of colors, supply no final evidences of the number of primary sensation qualities.

Scientific theories as to number of visual sensations which are primary.

The various scientific studies on this subject of the number of color qualities may be divided into three groups. One group regards red, green, and blue as the only primary colors, all others being looked upon as derived forms. A second group adds yellow, while a third group considers that there are an indefinitely large number, certainly more than four. The solution of the question, since it does not depend merely upon introspective observation, waits upon the complete formulation of certain facts which will be referred to in the subsequent discussions.

The color spectrum and circle.

More important than the determination of the exact number of primary color qualities is the presentation of a complete description of the series of color experiences. The most complete single series of colors known to physics is produced by passing a pencil of white light through a prism. The different colors which compose this ray of white light will be refracted to different positions, and the whole will be spread out into a colored band with red at one end and violet at the other. Between these lie orange, yellow, green, blue, in the order given. This series of colors produced from white light is known as the spectrum. Mixed colors are not present in the spectrum, notably purple, which consists of a mixture of red and blue. When purple is introduced into the series of colors, they constitute a series of qualities which seems to return upon itself. For this reason, the colors of the spectrum plus purple may conveniently be represented by a closed figure, either a triangle or a circle. The color circle is given in Fig. 23. Four, or better nine, color names are used to indicate

some of the chief qualities of the series, the exact number of such qualities being left somewhat indefinite, for reasons indicated above. Between the colors explicitly named in this circle, there are transitional forms of sensations.

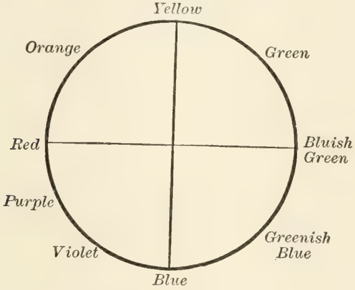


FIG. 23. Color circle. The center of the circle represents white. All colors placed at opposite ends of diameters of the circle are complementary colors.

There are also transitional forms of sensation from this color series to the gray series. Thus, from any color there is a series of sensations in which the color quality gradually fades into a colorless gray of the same intensity as the original color. Such a series is called a saturation series. The full color is said to be a saturated quality; the more the quality approaches gray, the less saturation it is said to have. Each color is also capable of variations in brightness. A red of great light intensity is said to have a high degree of brightness. A color of small light intensity is said to have a low degree of brightness. The relation of brightness to saturation is such that when a color becomes very bright or very dim, its characteristic quality tends to disappear. Finally, color qualities may be compounded so as to produce an unlimited variety of intermediate qualities. Saturation, brightness, and mixtures.

Complete color and saturation system never appears in experience at one time.

Our discussion of visual sensations has described series of qualities which are never presented together under the conditions of ordinary life. If one would see even approximations to the whole series of colors, saturations and grays, he must carefully prepare the conditions for the presentation of these sensations. In common experience, the objects around us present a series of contrasts and a manifold of unrelated and mixed qualities which, at first sight, seem to preclude any reduction to simple classifications. The first step of our psychological study has been, therefore, to discover and describe the primary and simple facts of visual sensation before proceeding to the study of the characteristics and conditions of such sensations. Our systematic description should not lead us to overlook the facts of ordinary life just recalled. In everyday experience, colors and shades of gray and grades of saturation are of value, because they mark contrasts and render discriminations easy. For science the arrangement of the full series in an order in which the effects of contrast are much reduced, is necessary for the sake of completeness. Such considerations as these show at once the relation of our preliminary study of sensations to the later and more complete study of common forms of experience.

External light.

Turning now from the series of visual sensations, let us review very briefly the characteristics of external physical light. The physicist recognizes physical light as a form of vibration in the luminiferous ether. These ether vibrations have three characteristics; namely, rate of vibration, amplitude of vibration, and complexity of vibration. For purposes of exposition, we may compare light waves to simple water waves, which are represented in outline in Fig. 24. In waves of this type, a single particle of water oscillates up and down in straight lines, while the wave as a whole travels in the horizontal direction.

The rapidity with which each particle oscillates is called the rate of vibration. The rate determines the length of the waves from crest to crest, so that we may refer to waves as having different lengths: rapid vibra-

Rate and length of vibrations, amplitude, and complexity.

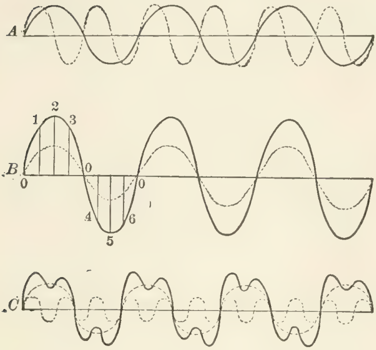


Fig. 24. The wave forms represented in *A* have like amplitude, that is, like range of movement above and below the horizontal line; but differences in rate, one wave being twice as rapid as the other. The waves in *B* are alike in rate, but different in amplitude. The lines *1, 2, 3, 4, 5, 6* show the paths of six single particles which participate in the larger wave motion. When a particle is in its original position, it lies at some point along the horizontal line, as at *0*. At successive periods it moves to the height, *1, 2, 3* or to the low level *4, 5,* or *6*. The wave motion passes from left to right. Any given particle oscillates upward and downward in a vertical line. The amplitude of a wave depends upon the extent of this movement of a single particle. *C* represents a complex wave form. The two regular waves, indicated in dotted lines, acting upon the particles together, result in the complex form of vibration represented in the full-drawn line.

tions corresponding to short wave lengths, and the slow vibrations corresponding to greater wave lengths. The amplitude of a wave is determined by the extent of the oscillations of each particle. The complexity of a wave depends on the mode of the movement of the particles; a complex movement results from the action of a number of wave impulses acting on the same particle at the same time.

Relations between physical facts and experience.

In the following table a comparison is instituted between the physical facts and the corresponding facts of sensory experience: —

Physical Facts	Facts of Sensory Experience
Simple light vibrations of medium amplitude	Color sensations
These simple vibrations appear in every possible rate, thus forming a single continuous series of variations in rate	The sensations differ in certain well-marked stages, forming a series of distinct color qualities, limited in number
These rates vary from less than 435 billion vibrations per second	No color experience (sometimes experience of warmth)
435 billion vibrations per second	Red
through all possible rates	Successive qualities (yellow, green, blue)
to 769 billion vibrations per second	Violet
and beyond	No color experience
Compound vibrations	(Either whites, grays, less saturated colors, or purples)
The compound sometimes consists of vibrations of about 435 to 500 billion per second, combined with those of about 660–769 billion per second	Purple
In some cases widely different rates are combined, sometimes in special pairs, sometimes in more complex groups	White
In some cases various rates other than those above mentioned are combined	Various grays and unsaturated colors
Amplitude variations	Changes in intensity and saturation
Increase in amplitude to the highest	Increase in intensity and decrease in saturation toward white
Decrease in amplitude to the lowest	Decrease in intensity and in saturation toward black

The differences between the physical series and the sensation series are so striking that much scientific in-

vestigation has been devoted to the effort to bridge over the differences, as far as possible, by setting between the two groups of processes described in the above table a third group of processes; namely, the physiological processes in the eye and central nervous system. Not infrequently it has been impossible, with the means of scientific investigation in our possession, to discover by direct observation all the physiological links between certain physical facts and certain facts of experience. In such cases, theories have been developed by science to fill the gap. These theories go beyond direct observation in their statements, but do so with definite regard to such facts as can be observed. We turn, therefore, to a consideration of some of the physiological facts and theories, taking up, as a necessary introduction to the physiological facts, a study of the structure of the eye.

Relation between the physical and the psychical facts depends in part upon the organs of sense.

The human eye is a complex organ, the product of a long series of evolutionary processes. If we study some of the simplest eyes, we shall be able to discover what are the relations of this sense to the general development of the nervous system.

Development of the visual organ.

It should be noted first that all organic cells are affected more or less by changes in the character of the illumination acting upon them. Thus, even before there is an organ of vision, the unicellular animal is affected by light. There appears even in the simplest multicellular animals a group of cells specialized for this function. In some of the lowest forms of life, for example, the jellyfish, it is found that at certain points on the surface of the body the cells of the nervous system are grouped into small spots of pigmented cells. (*See* Fig. 25 *A*.) The pigment is not a part of the nervous system, but it serves to absorb the light which falls upon this part of the animal's body more than do the unpigmented regions. The result is that the influence of the light is enhanced by the presence of the pigment, and the growth of larger and more sensitive sensory cells in the immediate neighborhood of these spots brings about a condition which is favorable to the reception of light. We may, for convenience, refer to

All protoplasm sensitive to light; pigmented protoplasm, especially.

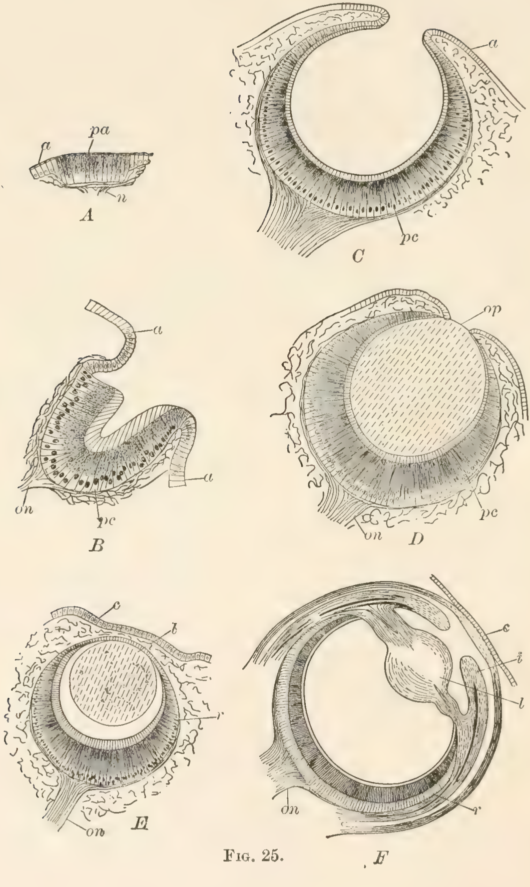


Fig. 25.

the pigment, since it is not true nervous tissue, as an accessory organ. We shall find in the study of later developments of the eye that the accessory parts of the eye are quite as important as the nervous organs themselves, the evolution of the two groups of structures going on in parallel lines.

Evolution of complex visual organs.

A higher form of visual organ is represented in Fig. 25, *B*. Here we find a larger group of cells sensitive to light stimulations. The pigment is present as in the most primitive eyes, and the whole organ is placed in a depression in the surface of the body. This depression serves to protect the delicate cells more effectively than they could be protected on the general body surface, as in the case of the jellyfish. This protection of the cells undoubtedly works to the advantage of the cells, furnishing them the conditions necessary for becoming more sensitive, while at the same time the wall of the depression furnishes them the space in which they become more numerous. In later stages of development, as indicated in the figure, the depression in the body wall is filled with a protecting fluid. This fluid is of a thick, gelatinous consistency and in the most primitive forms, translucent, not transparent. The light stimulation which acts upon the sensory cells of such an eye as this will obviously not be very intense or definite. Something has been sacrificed to protection in the fluid, which obstructs the light. This

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FIG. 25. Shows a series of eyes which have reached various levels of development. *A* shows a simple pigment spot. The ordinary epithelial cells which constitute the surface of the body are represented at *a*. The pigment particles represented at *pa* make this portion of the surface of the body more susceptible to the action of light. *B* shows a somewhat more highly developed organ. The surface of the body is here depressed so as to protect the sensory cells. These specialized cells are notably larger than the epithelial cells at *aa*. This is the eye of Patelia. *C* represents the eye of Nautilus. The central cavity is filled with water; *D*, a camera eye with a large lens filling its cavity; *op* represents the lens; *E*, camera eye with the cornea (*c*) covering the lens. Murex. *F*, complete eye with the lens (*l*), cornea (*c*), iris (*i*), and other portions as before. Cuttlefish. From Conn's *Method of Evolution*.

disadvantage is, however, more than offset by the fact that the fluid furnishes favorable conditions for increase in the number and sensitiveness of the cells. Such an eye as this cannot distinguish more than vague changes in illumination. An opaque object passing before the animal might, by its shadow, be recognized as something standing between the animal and the light, but the form or distance of the object certainly could not be recognized except through the intensity of the shadow and the period of its duration. A bright object would give a somewhat more definite impression, but nothing comparable to the impression received by the eyes of the higher animals.

Development of lens.

Later stages of development of the eye are represented in the figure. In *C* and *D* it will be seen that the outer covering of the eyes begins to develop a lens. In the earliest forms, this lens is spherical in shape. Such a shape is mechanically simple, but optically very imperfect. The image which it throws on the sensory surface is distorted and the different rays of light are focused at different points, causing the hazy colored fringes technically known as chromatic aberrations.

Although no attempt has been made to give a complete description of the various modifications which are presented in the evolutionary series, enough has been indicated to make it clear that the eye passes through a definite series of processes of development as we ascend the scale of animal life, and enough has been indicated of the structures of the eye to justify our turning immediately to the description of the highly developed form which we find in the human organ of vision.

The human eye.

The human eye is an independent organ separated from the body wall and placed in a protecting bony cavity or eye socket. Before taking up the internal structure of the eyeball it may be well to refer to the

External muscles.

external muscles which hold it in place and move it about independently of the head. These are very important accessory organs and increase the range of vision very greatly by making it possible to move the eyes easily without moving the head. The human eye

is supplied with six such muscles. By means of these muscles, the eye is capable of rotation, with the nicest adjustments in any direction whatsoever. In ordinary life the behavior of one eye is closely related to the behavior of the other eye, so that the muscles coöperate in producing certain binocular movements, and the single eye is not capable of moving except within certain definite limits. The extreme position of relaxation of the muscles would bring the axes of the two eyes into a position of divergence, so that the right eye would be directed toward the right side, while the left eye would be directed toward the left side. Such a position of divergence, while possible so far as the muscular structures are concerned, is impossible, because of the habitual use of the two eyes together. The extreme position which appears in ordinary life is one in which the axes of the two eyes are parallel to each other. The details of muscula activity need not be described here. It is sufficien to call attention to the fact that a right or left movement in the horizontal plane involves a simpler combination of muscles than upward and downward movements in the vertical plane.

The outer wall and the lens.

A sectional view showing the internal structure of the eyeball, is given in Fig. 26. It will be noted immediately that this organ is in many respects more highly developed than any of the eyes represented in Fig. 25. By the development of an independent outer wall of cartilage, the eyeball has been made a free portion of the body, as noted in the last paragraph. In the second place, it will be observed that the lens, which we saw in some of the lower forms as a spherical organ, has been elaborated in the course of animal evolution, so that it now has the very much more advantageous form of a double convex lens, indicated in the figure at *L*. This lens has certain other complexities in structure which tend to free it from the optical defects referred to above. It is not homogeneous throughout, and by means of the iris, or adjustable diaphragm, which is placed in front of it, only the center, which is the most

efficient portion of the lens, is utilized in ordinary vision. Furthermore, by means of certain muscles which form a circle around the lens and control a transparent capsule which surrounds it, the lens can be modified in form so that it is made more or less

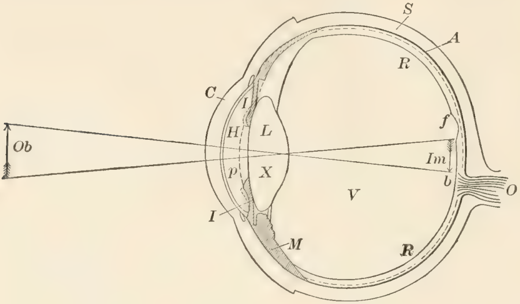

FIG. 26. Diagrammatic section of the human eye. *O*, optic nerve; *S*, sclerotic; *C*, cornea; *A*, choroid coat; *I*, iris; *R*, retina; *V*, vitreous humor; *H*, aqueous humor; *L*, crystalline lens; *X*, optic center of the lens; *b*, blind spot; *f*, fovea centralis; *p*, pupil; *M*, ciliary muscles, which control the curvature of the lens; *Ob*, object outside of eye; *Im*, image on the retina. From Wundt.

convex according as light which is to be focused upon the sensory surface comes from a source near at hand or far away. The details of this adjustment of the lens need not be discussed here; it is enough to call attention to the fact that when the eye is to look at an object far away, the lens is relatively less convex than when the eye is looking at an object near at hand. The adjustment is carried out reflexly. There are limits beyond which it is impossible for the lens to adjust itself; the near limit for the normal eye is about eight inches from the eye, the remote limit for the normal eye is at an infinite distance. Individual

imperfections in adjustment appear. For example, the lens in old age becomes somewhat less elastic than in early life and, because of this lack of elasticity, it is incapable of taking on a high degree of convexity. Other abnormalities appear, in that the far limit of certain eyes is at a relatively short distance in front of the eye; a person whose limit of remote vision is thus nearer than a point infinitely far away is described as near-sighted. Most of the defects in the functioning of the lens can be relieved more or less completely by the use of an artificial lens outside of the eye. The function of the artificial lens is exactly that of the lens in the eye, and the possibility of correcting defects in the lens of the eye by various combinations of glass lenses is limited only by the possibilities of physical optics. This makes it perfectly clear that the lens is not to be treated as a part of the nervous system, but rather as an accessory organ developed for the purpose of applying the stimulus to the organ of sense in such a way as to produce a clearly defined image on the retina.

Transparent media.

In the human eye, all of the media through which the light must pass are highly transparent. A certain portion of the outside coat of the eye; namely, that portion which lies directly in front of the lens, is transparent. Between this transparent wall, or so-called cornea, and the lens of the eye, there is a chamber filled with transparent fluid known as the aqueous humor. The lens itself is of a very high degree of transparency. Back of the lens is a mass of gelatinous matter known as the vitreous humor, which fills the whole eyeball and maintains the proper spherical form of the eyeball. These transparent media are products of evolution and show an important advance over the translucent gelatinous substances which we find in the more primitive eye.

Choroid coat.

The pigment layer which was seen in the most primitive eyes is present in the human eye in the so-called choroid coat. It covers the whole inner surface of the eyeball. It serves the same purpose as does the black lining of a camera; that is, it prevents the rays of light

which have acted upon the sensory surface from being reflected back so as to interfere with other entering rays. It is richly supplied with blood vessels, which provide for the nutrition of the sensory cells.

The retina. We have, up to this point, referred only to the accessory organs of the eye. We turn now to the examination of the retinal surface, which is the true sensory organ. It is made up of a series of layers of cells distributed over the inner surface of the eyeball and placed between the choroid coat and the vitreous humor. The retinal layer is represented in section in Fig. 27. The rods and cones, which constitute the inner layer lying next to the choroid coat, are undoubtedly the organs which are most immediately affected by the rays of light. The rods and cones are highly developed cells which are specialized for the reception of light stimulations. They may be thought of as small vessels containing chemical substances which are especially susceptible to changes under the action of light. The chemical activity, set up in the rods and cones by the light which enters the eye, liberates energy which is transmitted through the successive layers of cells represented in the figure, until finally it reaches the large nerve cells of the retina, indicated at the level VIII in the figure. The energy which originally entered the eye in the form of vibration in the luminiferous ether, is thus transformed into chemical action in nerve cells, and this chemical action in the nerve cells is transmitted to the fibers which pass out of the eyeball and communicate with the central nervous system.

Rods and cones and their functions. The rods and cones undoubtedly represent different types of receiving organs. The central part of the retina, which is more important for clear vision than other portions, is made up of cones exclusively. Passing from this limited central region of clear vision, known as the *fovea centralis*, toward the outer areas or periphery of the retina, the rods become more and more numerous. The functional differences which correspond to these structural facts can be easily observed. Let a colored light of moderate size and intensity be brought into the outer part of an observer's field of vision.

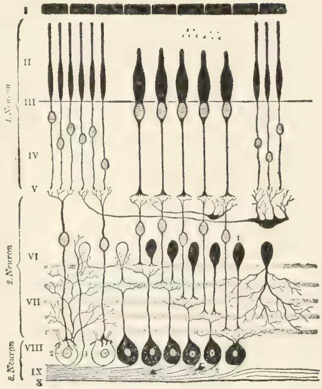

FIG. 27. Shows a diagrammatic section of the retina. After Greeff. *I* is the pigment epithelium, *II* is the layer of rods and cones. The rods are the small slender organs. In the retina the rods and cones are, throughout the larger part of the organ, mixed together; in the fovea only cones appear. *III, IV, V, VI, VII,* show various intermediate structures between the rods and cones and the nerve cells which are situated at *VIII*. From the nerve cells at *VIII* the optic fibers pass out, as indicated at *IX*, toward the blind spot, where they leave the eyeball. *X* represents the limiting membrane of the retina. A ray of light entering the eye passes through the retina in the direction from *X* to *II*. The light does not produce any effect upon the cells or fibers until it reaches the layer of rods and cones.

This light will cast its image on the periphery of the retina where the rods predominate, and the observer will not experience a color sensation, but rather a sensation of colorless light. If, now, the colored light is gradually made to approach the center of clear vision where the cones predominate, its color quality will become more and more obvious, until, finally, at the center of clear vision it will be clearly seen. We may state this result in general form by saying that the center of clear vision is also the center of color vision, while the areas at the extreme periphery of the retina are totally color-blind. The areas intermediate between the extreme periphery of the retina and the center of clear vision are partially color-blind; that is, they respond to a limited number of colors. This limitation of ability

to respond to colors is offset in the rods by a distinct advantage on the side of susceptibility to slight changes in colorless light. An observer very frequently has the experience early in the evening of seeing a faint star in the outer edge of the field of vision, and finds the moment he turns to look directly at the star that it is impossible to see it. The periphery of the retina was sufficiently sensitive to the slight illumination to make possible a sensation from the faint star, whereas the center of the retina was incapable of responding to this slight illumination. The significance of this differentiation of the retina in the development of the animal kingdom is evident. The periphery of the retina and the extreme edges of the field of vision do not have the same significance for the animal as the center. It is more advantageous that the animal should be able to concentrate its highest forms of nervous activity upon a limited area. On the other hand, it is important that the outer regions of the retina should be sensitive in such a way as to give immediate warning of any changes in illumination, for changes in illumination mean movement, possibly the approach of danger, and this should be recognized sufficiently to warn the observer. If, then, it is desirable to give the object stricter attention, the eye can be turned so as to bring the image upon the center of clear vision.

Color-blindness.

The differentiation between the different parts of the retina, which has just been described as characteristic of the normal retina, does not always appear. There are certain persons whose eyes are not fully differentiated for colors; these persons have at the center of the retina a condition similar, at least so far as color processes are concerned, to that which appears toward the periphery of the normal retina. This inability to respond to different color stimulations may in some cases be complete, so that the individual sees the world as a normal individual sees an engraving; that is, as if it were made up only of differences in light and shade without the qualitative differences which we describe as color differences. A much larger number of individuals have a partial deficiency, analogous to

that which appears in the intermediate zones of the normal retina. The various forms of partial color-blindness are extremely difficult to define with precision, for the simple reason that the color sensations of the partially color-blind individual constitute his world of color sensations. He usually has no means of comparing his experiences with those of the normal individual. His efforts to describe his own experiences to a normal individual are complicated by the necessity of using terms devised for the normal individual, rather than for his own peculiar experiences. Fortunately for science, there have been a few cases in which the same person has been able to observe directly both the normal color sensations and the partially color-blind series. The defect in such individuals appears only in one eye, while the other eye is of the normal type. It has, furthermore, been possible by certain methods of comparing color mixtures to make an analysis of other cases of color-blindness. The net result of these investigations has been to show that the color series of a partially color-blind individual is of a simpler type than that of the normal individual with a fully developed retina. One very common form of partial color-blindness, known as "red-green blindness," has been thoroughly investigated. The following table shows the comparison between the normal color system and the two types of red-green blindness, which have been worked out: —

Normal	Type I	Type II
Red	The red end of the spectrum short, what is seen is gray, or unsaturated yellow	Yellow
Orange	Unsaturated yellow	Unsaturated yellow
Yellow	Unsaturated yellow	Unsaturated yellow
Green	Yellow	Gray, or unsaturated yellow
Blue	Blue	Blue
Violet	Violet	Violet

Such facts as are shown in this table, and in the cases of total color-blindness, emphasize the intimacy of the

Dependence of sensations on physiological processes.

relation between retinal development and the development of experience. They make it clear that the number of sensation qualities which an observer has, depends not upon the number of physical processes in the outer world, but upon the number of physiological processes which are aroused in the nervous system by the various kinds of physical energy. In general, we may safely accept the principle that there is a direct correspondence between the number of sensory qualities in consciousness and the number of physiological processes in the nervous organs. The term nervous organs is left somewhat general in this statement, because it is not certain that the retinal processes and the central nervous processes always correspond directly to each other. It may be true in certain cases that the number of processes in the peripheral organ is again changed as these processes are transmitted through the central organs.

Correspondence or parallelism between conscious, and physiological processes.

The principle of correspondence between conscious processes and processes in the nervous system is a fundamental principle in psychology and physiology. It is used in inferring the number and character of the physiological processes from the number and character of conscious experiences. Thus, after deriving from physiological investigations the general formula that there is chemical activity in the retinal elements, the details are worked out very largely through an observation of the facts of experience and an application of the principle stated above, that the number of experiences corresponds to the number of physiological processes. We do not hesitate, therefore, in describing the facts in the following terms: When an observer sees red, this is due to the fact that red light enters the eye and falls upon organs which are capable of responding with a distinct chemical process. Since the experience of red is clearly different from many other color experiences, we conclude that the effect of red light upon the chemical substances in the cones is such that a distinct kind of chemical process is produced; and when this particular kind of chemical process is transmitted to the central nervous system, the central

process arises which is the immediate condition of the sensation red. If, instead of the red ray of light, a ray of yellow light enters the eye and acts upon the chemical substances of the cone, there will result in the normal retina a process differing from that induced by the red ray, as is evidenced by the fact that the normal observer has, under the conditions described, a different type of sensory experience. So, through the whole series of simple colors, there must be a corresponding series of chemical processes in the receiving organs. Such a formula is immediately applicable in explaining color-blindness. We have simply to assume that the retina of the color-blind observer is not capable of responding with the same number of chemical processes as the normal retina. The degree of deficiency in retinal processes can be ascertained in any given case by a complete study of sensory experience.

Correspondence between nervous processes and sensation.

In the remaining discussions of sensory processes, the formula of correspondence between conscious processes and processes in the sense organs will be freely used. The student should recognize that the transition from observed experience to retinal process is a matter of inference. Many of the details are even now subjects of discussion, because they depend on inference. It is safe to assert, however, that the chief characteristics of the physiological processes are made out, and that the knowledge which we have is sufficiently exact to be characterized as definite and certain. The doubtful conclusions which are recognized as theories will be referred to later.

Color-mixing.

Another group of facts closely related to those discussed above are the facts of color-mixing. If a given point on the retina is stimulated at the same time by two or more rays of differently colored light, the chemical process set up cannot be the process which is appropriate to either color acting alone. Experience shows that the process is a compromise between the processes which would have resulted if each ray had acted alone. Thus, if at the same moment a ray of red light and a ray of yellow light fall upon a single cone, the result is that the observer sees orange, which

corresponds in quality to the color lying in the spectral series intermediate between red and yellow. The orange quality resulting from this compromise between the red process and the yellow process is not as saturated as the orange which appears when the cone is stimulated by a single pure orange ray; it has a slight admixture of gray. If, instead of merely using red and yellow, we use red, yellow, and blue at the same time, we find, by observing the resultant sensation, that a compromise between the three chemical tendencies in the cone is very different from any one of the processes taken alone. Indeed, in such a case, the retina is not capable of giving a compromise color process, but falls back into the process which the study of color-blindness shows to be the most primitive form of chemical activity; namely, the chemical process corresponding to gray, which we found as the only process in the eye of the totally color-blind person and in the periphery of the normal retina.

Purple. If a red ray is mixed with a blue ray, a unique compromise process results, which is not directly related to any of the simple colors of nature; namely, the process which gives rise to a purple sensation. Purple is a color quality which can be explained only in terms of the retinal process. Red and blue, which are the physical facts conditioning the experience of purple, are further removed from each other in the physical spectral series than are most of the colors in the spectrum, yet they fuse easily so as to give a strong sensation quality. This goes to show that the retinal processes for red and blue are closely related in character, in spite of the great difference in the respective rates of vibration in the physical processes which excite these retinal processes. The color circle which was described in an earlier paragraph is, therefore, not to be explained as a physical circle, but as a circle of retinal processes and corresponding experiences. Indeed, it may be said in general that the laws of color-mixing are primarily laws of retinal behavior, rather than laws of the physical world. The fact that all the colors of the spectrum when mixed together produce

gray is, as has been pointed out a number of times, a physiological fact and a fact of experience, rather than a fact of physical vibrations.

General principles of color-mixture.

The principles of color-mixtures were worked out first by physicists and have furnished a basis for most of the theories of color vision. Briefly stated, the general principles of color-mixing are as follows: When two colors near each other in the spectral series enter the eye at the same time, there results a sensation and a retinal process which is intermediate to those demanded by the two colors when they act alone upon the retina. This intermediate process is not the same as that which would result from stimulation of the retina by the intermediate pure color, for the sensation is not as fully saturated as it would be if it had resulted from the action of a pure color. As the distance between the two colors of the mixture is gradually increased, the chromatic quality of the resultant grows less and less marked, until finally the sensation is of the simplest possible type; namely, the sensation gray. This shows that the retina is forced by certain mixtures of very different colors to return to the simple undifferentiated form of activity which characterized it before the differentiation into chromatic qualities began. Two colors which are opposed to each other in such a way that they give when mixed no color whatsoever, but merely the sensation gray, are known as complementary colors. If the distance in the color circle between two colors which enter into a mixture is greater than that required for the complementary effect, the resulting color will be some shade of purple. If purple is introduced in the color circle, there is no shade of color which does not have its complement. The color circle shown in Fig. 23 may be made, therefore, the basis for discussion of complementary pairs, provided the arrangements of the colors opposite each other are made with this end in view. If more than two colors are mixed, the total result will be the sum of the partial effects, and can be foreseen by considering the partial processes as if they occurred successively.

It may be well to call explicit attention to the fact

Pigments follow a physical law of mixture.

that the statements here made regarding color-mixtures do not apply to mixtures of pigments. The mixture of pigments is a physical fact, not a physiological process. The action of pigment on light is to absorb certain rays and reflect others. Mixtures of pigments affect light in a complex way, and hence produce results which cannot be explained by merely inspecting the separate pigments. Whatever the result of mixing pigments, however, the process is a physical process and its result depends upon the ability of the pigments to absorb and reflect rays of light.

After-images.

The consideration of certain other facts is necessary to complete the discussion of visual sensations. If light acts upon a retinal element for a given period, the effect will continue for a time after the external light ceases to act. The observer will notice what is known as an after-image of the light at which he has been looking. Every one has doubtless observed the vivid after-images which result from looking at the sun or other very bright objects. Most of the after-images which we receive from ordinary objects are so faint that they are overlooked, unless special effort is made to notice them and to retain them. In general, the experience which continues after the withdrawal of the external light resembles only for a very brief interval the sensation originally produced by the external light. So long as primary experience and after-image are of the same quality, the observer is said to have a positive after-image. An example of such a positive after-image can easily be secured by rapidly rotating a burning stick in a circle, when the observer will see an uninterrupted circle of light, because the stimulus returns to each of the points of the retina before the original process has had time to change. Very soon after the external stimulus is withdrawn, experience undergoes a radical change. The general principle of this change may be described by saying that every black changes to white, every white to black, and every color to its complement. Since these changes are known from the conditions to be due to physiological processes, rather than to external light, we describe the conditions for these

after-images in the following terms: The retina tends to set up as soon as possible a process opposite to that which was produced by the original stimulus. This chemical process, opposite in character to that produced by the external stimulus, is due to the tendency of the physiological organism to restore the chemical substances which have been used up in the first process of stimulation. The experience of the observer follows, during this process of recuperation, the retinal activity, rather than the external physical fact. Thus, after looking for a time at a brilliant red light, the observer sees very soon after the light is withdrawn a colored area of like spatial form and extent as the original, but of a quality exactly complementary to the red; namely, green. In like fashion, the negative after-image of a blue surface is yellow. If the stimulating surface is black and white or gray, rather than colored, the negative after-image will be of such a character that what was bright in the original image will appear dark in the after-image, and, conversely, what was dark in the original image will appear white in the after-image.

Contrasts. After-effects in the retina very frequently operate to modify the retinal processes produced by subsequent light stimulations. For example, let an observer who has been looking steadily at a bright red light for a time and has a strong tendency toward a green after-image, look at a blue surface; the blue surface will not be seen in its normal color, but will be seen as a mixture of blue and green, the green being contributed in this case by the after-image process in the retina. The mixtures between after-effects and color stimulations here under discussion give rise to many forms of color contrast. In view of the continual movement of the eye from point to point in the field of vision, the observer is always carrying more or less marked after-effects from a given part of the field of vision to the neighboring parts. If, for example, a red and a green field are placed in close juxtaposition, and the eye after looking at the red surface tends to move in such a way as to bring a portion of the retina which has been stimulated by the red into a position such that it will

be stimulated by the green light, the green sensation received from the summation of the external stimulation and the after-image will be more intense than a green sensation received without the preliminary stimulation from a red. The result is that green seems to be more saturated when it lies near red. In general, every color is emphasized by being brought into close relation with its complementary, and grays tend to take on colors complementary to surrounding fields. The tendency of grays to take on colors may be well illustrated by shadows. If a field which is illuminated by a yellow light is interrupted by a shadow which is, in reality, gray, this gray shadow will take on a bluish tinge by contrast with the yellow field. This fact has long been observed by those who reproduce the colors of nature in painting, and the shadows in painting will usually be found to be, not reproductions of the physical facts, but rather reproductions of the impression made upon the observer.

Sensation and its conditions. Enough has been presented in the discussion of these facts to show the value of a physiological theory of the relation between sensation and physical stimulus. The differences between objective facts and subjective experiences which were so clearly pointed out by the physicists are here explained by the recognition of an intermediate physiological link. The unique subjective character of sensations is in no way ignored by such studies. The sensation of red is not identified with the retinal processes or with the vibration in the external world, but objective vibration, physiological process, and subjective sensation are shown to be parts of a coherent system of facts. The general conclusion here reached will be reiterated in all the later studies of sensation.

Theories of color vision. It remains to add a few remarks concerning the less certain conclusions regarding the relation between light sensations and external ether vibrations. The effort has frequently been made to describe the physiological processes in a single comprehensive formula or theory, which shall include all the facts. No attempt will here be made to review all of those theories. It will be

enough to present one of the simplest and most suggestive, and leave it to the student to criticise and reconstruct it in the light of the facts discussed above and reviewed in the tables given below.

Mrs. Franklin's genetic theory of processes in the retina.

The theory which was formulated by Mrs. Franklin is as follows: The primitive retina of the lower animals, and the periphery of the human retina, have only one chemical process with which to respond to all light stimuli. This single chemical process, when set up through the action of light, arouses in the central nervous system a process which is the condition of a gray sensation. This is the original undifferentiated type of retinal activity. As the evolution of the retina goes forward, this original chemical process, which may be called the gray process, is so subdivided that colors produce certain partial phases of the original chemical activity. The partial chemical activities produce each a specialized form of nervous process and a specialized form of sensory experience. The breaking up of the gray process into special color processes begins with a development, first, of the partial processes which correspond on the one hand to blue, and on the other hand to orange or yellow sensations. This first differentiation corresponds to the wide difference between the extreme ends of the spectral series. The original gray process does not disappear with the rise of the blue and yellow processes, but remains as the neutral and more general form of response. At this stage the yellow and blue processes are each called out by a great variety of stimulations. Thus, the yellow process is aroused by red light, orange light, and green light, as well as by yellow light. As the development goes on, the yellow chemical process is subdivided into more highly specialized processes, corresponding to red and green. The result of this successive differentiation of process is that the highly organized retina may, when stimulated by the appropriate form of light vibration, respond with specialized chemical processes to red, green, yellow, or blue. If yellow and blue, which were the first forms of light to arouse differentiated processes, act at the same time upon the retina, the partial

processes which are differentiated out of the gray cannot both be in action at once without being swallowed up in the original fundamental process of gray. If red and green act together upon the retina, the yellow process appears as the more fundamental form of chemical process. The facts of color-blindness can be explained by stating that the differentiation of chemical processes is not complete in the color-blind eye. Negative and complementary after-images are due to the physiological instability of the partial chemical substances left in the retina after a process in which a colored light has partially disintegrated the retinal substance. Contrast has been included by earlier discussions under the same head as after-images.

The student will see at once that many of these statements are hypothetical. They serve, however, to gather together the facts, and they give a genetic account of primitive as well as of present retinal conditions. The theory or hypothesis should be clearly distinguished from the facts. In order to keep the facts clearly in the foreground, it may be well to return to a general summary of the different groups of facts discussed in this section.

TABLE A

COLOR-BLINDNESS

PHYSICAL FACTS	PHYSIOLOGICAL PROCESSES	SENSATIONS
I. Full series of simple vibrations	Highly developed retina with, however, a limited number of modes of response to external light	A differentiated group of sensation qualities.
II. Full series of simple vibrations	Partially developed retina with a number of possibilities of response to external stimulation, which is more limited than in the normal retina	Partial color-blindness
III. Full series of simple vibrations	Retina so little developed as to have only one mode of response	Total color-blindness

TABLE B

Color-mixtures

Physical Facts	Physiological Processes	Sensations
I. Series of simple vibrations	Highly developed retina with a limited number of distinct modes of response	Limited number of sensation qualities, constituting a series of distinct qualities
II. Two simple waves closely related in number of vibrations entering the eye together, thus making a compound wave	Retinal response which compromises between the two responses which would have resulted, had the two vibrations acted separately	Single color sensation somewhat less saturated than in the simple series
III. Two simple waves, very different in number of vibrations entering the eye together, thus making a compound wave	Retinal response which tends to take the simplest and most general form of retinal behavior	A color very little saturated, or a single purple or gray
IV. Large numbers of waves entering the eye together, thus making a most complex wave	Simple response of the rudimentary type	Gray

Without involving any of the more complex hypotheses, these tables are very successful in explaining away many of the differences between the physical series and the sensation series. We can understand very clearly why the consciousness of white light is so simple, when the external fact is so complex.

Conscious sensations are related to their conditions, but not identical with them.

TABLE C

After-images and Contrasts

Physical Fact	Physiological Processes	Sensations
I. Strong light vibration followed by withdrawal of physical light	Response followed by a continued action of the retina and a final reversal of the retinal process to restore the tissue to its normal condition	Color sensation continuing after external light and then changing into complementary color quality

We can understand why sensation qualities are limited in number. There is, however, even in these final tables, nothing to lead us to identify sensations of color with physiological processes, or with ether vibrations. A sensation of red may be related to certain processes in the retina, which, in turn, are related to a physical stimulus, but the sensation is a conscious fact depending on the existence of a conscious being, quite as much as upon the existence of physical light or retinal processes. Just as the retinal process can be explained only by recognizing that the retina responds, according to its own nature, to a light stimulus, so the sensation process is quite as much the expression of the nature of the conscious being as the result of any external conditions. When we come to define a color sensation, therefore, we must point out that it is a mode of consciousness. As a mode of consciousness it is fundamental; that is, it cannot be reduced to any more elementary conscious fact. It may enter into a more complex conscious process as one of the factors which compose it, but no explanation can be given of its nature except to say that it is one of the ultimate forms of consciousness. If we take our position outside of consciousness for the moment and consider all the relations in which the sensation stands, we may add to our definition certain statements about

conditions, about retinal processes, and ether vibrations, such as have been outlined above. Consideration of ether vibrations and retinal processes is necessary to a complete science of sensations. Ether vibrations are the remote conditions; retinal processes, the immediate conditions. A visual sensation is, accordingly, a fundamental element of experience which arises in consciousness under certain conditions of retinal stimulation, this retinal stimulation being, in turn, induced by the action of external vibrations of the ether.

B. Auditory Sensations

The task of defining sound sensations and of describing their conditions will be a comparatively simple one on the basis of the elaborate study already made of visual sensations.

Physical sound. The physical stimulus which causes the nervous processes, which, in turn, condition auditory sensations, consists of longitudinal air vibrations. When a vibrating body strikes the air particles about it as it vibrates backward and forward, the air particles are alternately driven together and rebound from one another. Successive waves of condensation and rarefaction result, and these waves are carried forward in all directions until they strike some receiving surface, such as the ear. These air vibrations can be defined in the same terms of rate, amplitude, and complexity as were used for the light vibrations in the preceding section (page 78).

Pitch or tonal quality. With regard to the relation between sensation and external sound vibration, it is to be said, first, that when the objective waves are regular and relatively simple, they give rise to our experience of tone, the rate of the regular vibration being directly related to differences of pitch in tonal experience. Middle *c* on the piano scale has a rate of vibration of five hundred and twelve double vibrations per second. Toward the bass end of the scale, the vibrations decrease in rapidity, while toward the treble,

they increase. The lowest rate which is ordinarily heard by the normal ear is about thirty-two vibrations per second, although rates of sixteen, or even ten, per second have been described by some observers as audible. At the upper end of the scale one can hear vibrations of thirty thousand to forty thousand per second. Ordinary insect sounds are of this order.

Intensity or loudness.

Intensity of tone varies according as the amplitude of vibration of the single air particles is great or small.

Complexity of a regular type, giving differences in timbre.

The ordinary sounds which we experience result from complex waves. If two or more forms of vibration are transmitted to a given particle of air at the same moment, the particle will move in a path which will be the resultant of all of the different paths through which it would have moved, had the various impulses of vibration acted upon it successively. When one compares a given tone from the piano with the tone of the same pitch from a violin, he will recognize that the characteristics of the tones are different, though they are of the same pitch. The violin string vibrates, not only as a whole, but also in certain sections, and the piano wire vibrates as a whole, and at the same time in sections. The rates of vibration of the string and wire as wholes may be exactly the same. The sections in the two cases and the rates of their vibration will nearly always be different. The result is that any particle of air set in motion by either piano wire or violin string will have its main path determined by the vibration of the whole wire or string, while the minor details of vibration will be determined by the vibrations of the sections of the wire or string. The phase of tonal quality thus determined by the complex of minor vibrations is known as timbre. The main or fundamental tone is modified by the minor higher tones or overtones. Tones of the same pitch derived from various instruments have various timbres, just in so far as they have different overtones.

The experience of noise is dependent upon a form

of vibration which is so complex as to be highly irregular. A vague regularity appears in most noises. We speak, accordingly, of certain noises as low and rumbling, and of others as light and shrill, but for the most part the tendency toward regularity of vibrations gives way in noises to a confusion of irregular oscillations in the air particles.

Complexity of an irregular type, giving noise.

Turning from the physical stimulus to the auditory organ, we find here, as in the case of the eye, that by a long process of evolution there has been produced a sensory organ which has a variety of accessory parts and a delicate sensory surface, which latter transforms the air vibrations into nervous processes. The most primitive ear, such as is found in the cœlenterates, consists in a sack-shaped opening in the side of the body. This sack-shaped depression, or vesicle, contains hard calcareous particles, and is lined by sensitive cells which are similar in their general appearance to the cells in the primitive eye. The whole organ can be easily explained by comparing it to an ordinary child's rattle-box. If the animal is shaken, or if any sound vibrations strike against the wall of the vesicle, the calcareous particles, or otoliths, as they are called, are set in motion and tend to strike against the sensitive cells. The result is that the cells will be stimulated by each movement of the animal's body, or by the vibrations which enter the vesicle. As the ear develops through the animal series, there appear a number of accessory organs which serve to facilitate the reception of vibrations, and there comes to be a division between the two functions of sensory response to the movements of the body as a whole, and response to vibrations from the water or air.

Evolution of the ear.

After this brief reference to the primitive ear, we may turn immediately to a description of the human ear. The outer cartilaginous organ, known as the pinna, has in man very little function. It serves in a rudimentary way to concentrate the sound waves and direct them toward the inner ear. The cylindrical canal which connects the surface of the body

The human ear Pinna, meatus and tympanic membrane.

with the inner cavities of the ear is known as the external meatus. This canal is liberally supplied with protective bristles, and with secretory glands which tend to protect the ear from all foreign particles,

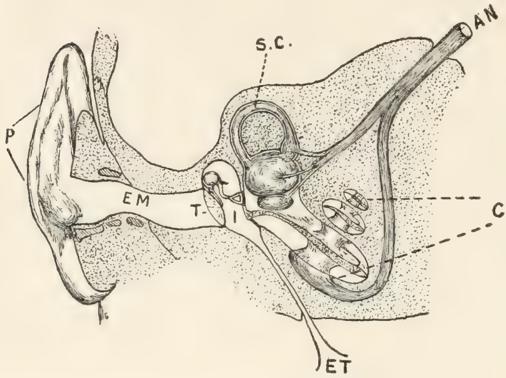

FIG. 28. Diagrammatic section showing the structure of the ear, modified from Czermak. *P*, the external pinna; *EM*, the external meatus; *T*, tympanic membrane; *I*, internal meatus or tympanic cavity. Extending from the tympanic membrane to the inner ear, there are three bones constituting the chain of ossicles: the malleus, incus, and stapes. The Eustachian tube (*ET*) passes from the internal meatus to the cavity of the throat; *SC*, one of the three semicircular canals; *AN*, the auditory nerve which divides into four parts as indicated in the figure, one branch connecting with the semicircular canals, two with the parts of the vestibule, and the fourth with the core of the cochlea (*C*). The canals of the cochlea are indicated in general outline; for details see Fig. 30. The vestibule is the general region lying between the canals and the cochlea.

and it is curved in shape so that nothing but very small, slender objects can penetrate to the inner parts of the ear. The inner end of the meatus is closed by means of a circular membrane, known as

the tympanic membrane. This tympanic membrane is a composite membrane made up of circular and radial fibers. It is slightly depressed in the middle so as to be somewhat funnel-shaped, and is loaded by being connected on its inner surface with a small bone, known because of its shape as the malleus, or hammer. The malleus is controlled by a small muscle, known as the tensor tympani. When this muscle is contracted, it draws the malleus inward, and with the malleus the tympanic membrane, thus increasing the tension of the membrane and emphasizing its funnel-shaped form. The adjustments of the tympanic membrane, as well as its shape, are of importance in giving the ear the largest possible range of ability to receive sound vibrations. No artificially constructed diaphragm, such as those employed in the phonograph or telephone, is capable of as wide a range of response to tones as is the adjustable, complex diaphragm in the ear.

Air chamber on inner side of the tympanic membrane.

In the functioning of the tympanic membrane, a difficult mechanical problem arises, because the air pressure in the external world is constantly undergoing changes. With every change in the barometric pressure there would be an interference with the action of the tympanic membrane, if the spaces behind this membrane were air-tight. Nature has, accordingly, provided on the inner side of the tympanic membrane an air chamber communicating with the atmosphere so that any change in atmospheric pressure will result in an equal change in the pressure on both sides of the tympanic membrane. This air chamber on the inner side of the tympanic membrane is known as the internal meatus or tympanic cavity. It consists of an irregular cavity in the bone, which is in communication with the throat by means of a small canal, known as the Eustachian tube. The wall of the Eustachian tube is flexible, so that it collapses except when a current of air is forced through it by a change in pressure, either in the internal meatus or in the external atmosphere. For this reason, the ordinary voice vibrations which

arise in the throat are not communicated directly to the internal meatus.

Chain of ossicles.

Since there is an air chamber on the inner side of the tympanic membrane, there must be some means of carrying the sound vibrations received on the tympanic membrane across this cavity to the inner ear. The means for transmitting the vibrations received by the tympanic membrane consist of a chain of three small bones, known as the chain of ossicles. The first of these ossicles has been mentioned; it is the malleus or hammer, which is attached by its long arm to the middle of the tympanic membrane. The head of the malleus articulates with the surface of the second bone, which is known as the incus because of its anvil-shaped appearance. One of the branches of the incus articulates in turn with the third bone, known as the stapes or stirrup. Any vibration received by the tympanic membrane is thus communicated to the stirrup. The stirrup fits into an oval opening, known as the fenestra ovalis, which leads into the inner ear. The stapes is connected with the walls of this fenestra ovalis by means of a membrane, so that it constitutes a tight-fitting piston which can move backward and forward in the fenestra ovalis. Beyond the oval window, the inner ear is filled in all of its parts with lymphatic fluid. Sound vibrations, which are originally vibrations of air particles, are thus transformed by the mechanism described, into vibrations in the lymphatic fluid which fills the inner ear.

The inner ear. First, the vestibule.

The inner ear is divided into three principal parts. The first is the vestibule. This is an irregular ovoid cavity about one fifth of an inch in diameter, which opens on the one side into the snail-shell-shaped cavity, known as the cochlea, and on the other into a system of slender canals, known as the semicircular canals. The vestibule itself is divided into two parts, known as the saccule and utricle.

The semicircular canals are not organs of hearing. They are organs which have taken up in the process of evolution that function of the primitive ear which

was concerned with response to the grosser movements of the animal's whole body. There are three of these canals, and they lie in such positions that each one occupies a different plane in space. Any change in the position of the head, or of the body as a whole, will cause a redistribution of the pressure within the system of canals, and this change in pressure affects the nerve cells which are distributed in the wall of the enlarged portion, or ampulla, of each canal. The whole system of canals serves as an organ of equilibration. The sensory stimulations which come from this organ do not give rise in developed human beings to clearly marked sensations. The result is that the ordinary observer does not know that he has a special sense organ of equilibration. The stimulations are for the most part taken up by the lower centers of the nervous system, where they are distributed to the muscles which keep the body erect; they probably never reach the higher regions except in company with a great mass of other excitations, and they are never sources of clearly defined experiences except when they are of unusual intensity. When they become excessively intense, they give rise to the experience of dizziness. In some cases the indirect effects of their action come into consciousness. When the reflex muscular adjustment carried out by the lower centers is unusual, as when one descends suddenly in an elevator, the muscular reactions, rather than the primary sensory stimulation, give rise to a clearly recognizable experience. The observer feels an unusual tension in his abdominal muscles, or muscles of some other part of the body.

The semicircular canals.

Turning from the semicircular canals to the other canal leading out of the vestibule; namely, the cochlea, we find here the organs which are concerned in the reception of tonal stimulations. It is not clearly known whether noise stimulations are received in the cochlea, or not. The probabilities are that noise stimulations affect certain cells constituting sensory areas in the wall of the vestibule. At all events, it is true that there are cells situated in the

The cochlea and sensory areas in the vestibule.

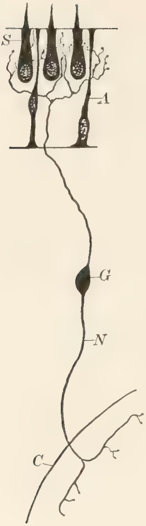

FIG. 29. Diagrammatic section of the sensory cells in the vestibule. The receiving cells are situated on the surface, as represented by *S*. These receiving cells are surrounded by supporting cells, as indicated at *A*. The nerve fiber is distributed among the receiving cells. The true sensory cell at *G* is in the ganglion, rather than directly at the surface. This sensory cell sends its second fiber inward to the central nervous system, represented by *C*. From Herrick.

wall of the vestibule which seem to be suited to the reception of simple stimuli. (*See* Fig. 29.) The genetic connection of the vestibule with the primitive ear, for it is the direct descendant of the primitive vesicle, would also seem to argue in favor of the view that noise stimulations, which are undifferentiated and probably earlier than tonal stimulations, affect these cells in the vestibule. Whatever may be true of noise, it is certain that the tonal excitations are received through the complicated structures which have been developed, and appear in the cochlea. The cochlea is a highly differentiated organ, richly supplied with cells and fibers for the reception of a great number of different stimulations. It consists of a double spiral canal, which winds around two and a half times. The winding of this canal is merely an anatomical device for compressing the whole organ into as small a space as possible. The canal, which is cylindrical in form, is divided into three parts, — the scala vestibuli, the scala tympani, and the ductus cochlearis. This division can best be seen by making a section across the cylindrical passage. Figure 30 shows such a section with the division. The scala tympani is partially separated from the rest of the cochlea by a bony shelf which extends for some distance into the canal. The division is completed by an impor-

tant membrane. This membrane, known as the basilar membrane, is made up of a series of fibers which differ in length as the membrane passes from the lower to the upper extremity of the canal. At its lower extremity the fibers are about one twelfth of an inch in length, and at the upper end of the canal they are about twice as long. Helmholtz, the great German physicist, called attention to the striking similarity between the structure of the basilar membrane and the system of strings of a musical instrument capable of giving a variety of different tones. He also advanced the hypothesis that the fibers of the membrane are so related to external tones that a given fiber is set in vibration by each particular rate of vibration. It is a well-known principle of physical science that any fiber or rod will vibrate sympathetically with a tone which has the same rate as it would assume itself, if it were set in vibration by some other cause. This principle is known as the principle of sympathetic resonance. The basilar membrane is so situated that the vibrations which enter the inner ear through the fenestra ovalis reach it by passing up the scala vestibuli and the ductus cochlearis. The scala tympani is a canal which carries back the vibrations after they have acted on the basilar membranes. It is connected at the upper end of the cochlea with the scala vestibuli, and serves to conduct away the vibrations, rather than allow them to be reflected back into the vestibule; for its lower end does not open into the vestibule, but communicates through an opening, known as the fenestra rotunda, with the internal meatus. The basilar membrane thus stands in the direct path of the vibrations, and it is, probably, the organ which takes up the vibrations and makes them effective in exciting the sensory cells.

Sensory cells in the cochlea.

A system of receiving cells, analogous to the rods and cones in the eye, is placed directly on the basilar membrane. At any given point they form an arch extending across the membrane and, therefore, capable of taking up any vibration which sets the fibers of the membrane in motion. The arch of cells is shown

The nervous processes in the ear are more directly related to external vibrations than are the processes in the retina.

in Fig. 30, and is known, from the physiologist who first described it, as the organ of Corti. Among the cells that constitute the organ of Corti, there are distributed nerve fibers which come from auditory ganglion or true sensory nerve cells situated in a cavity in the bony core of the cochlea. Whenever the cells of Corti are set in vibration, they excite the fibers. The external air wave is thus transformed in the organ of Corti into a nervous process.

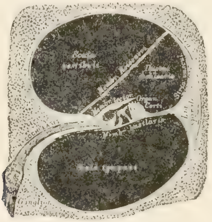

Fig. 30. Shows the structure in the cochlea as seen when a transverse section is made across the canal. The parts are clearly marked in the figure. Special attention should be given to the basilar membrane and the organ of Corti situated upon it. The nerve fibers are distributed among the cells of the organ of Corti from the ganglion in a manner similar to that represented for the vestibular cells in Fig. 29. From Herrick.

It is to be noted that the transformation is of a distinctly different type from that which takes place in the eye. In the eye, the physical stimulus produces a chemical activity in the rods and cones. In the case of the ear, the stimulus continues in the form of vibrations until it produces its final effect upon the nerve fibers. There is a less fundamental change in the character of the stimulus as we pass from the external world to the nervous process in the ear, than there is in the corresponding transition in the eye. This fact shows itself most clearly when we come to deal with compound sound vibrations. It makes no difference how many tones are sounded before the tympanic membrane, the complex vibration will be faithfully transmitted by the chain of ossicles and the other accessory organs, and will, at all points in its transmission, be a faithful reproduction of the total complex of sound impulses which gave rise to it. Furthermore, it is shown by an examination of sensory experience that

there must be a separate sensory process for each component of the tonal complex. If an observer listens to a tonal complex, the sensory excitations do not fuse as do the chemical processes resulting from a number of colors which act upon the retina together. Each tone in the complex retains its independent value for experience. It was this fact, together with the form of the basilar membrane, which led Helmholtz to suggest his hypothesis. Whether that particular hypothesis is true or not, we may confidently assert that the different parts of the organ of Corti are specialized in some way or other, so that each rate of external vibration, whether it reaches the cochlea alone or as part of a complex of vibrations, excites a particular part of the sensory organ, and so gives rise to a distinct sensory process.

Beats, difference tones.

There are certain special cases of complex air vibration which should be mentioned in this discussion of sensations. If two closely related tones are sounded together, they will reënforce the vibration of the air particles which they affect so long as their phases are alike, but the moment their phases come into such a relation that one tends to set the air particle vibrating in a given direction and the other tends to set the same air particle vibrating in the opposite direction, they will partially counteract each other in such a way as to keep the air particle for a moment in a state of equilibrium. Figure 31 represents, in the form of a water wave, two vibrations which at the outset coöperate in giving a larger wave. As one lags slightly behind the other, they come later to counteract each other in such a way that no vibration takes place, as shown at *M*. The result of such a combination of tones, which is a purely physical affair, is that the observer receives not only the two primary vibrations, but also a series of rapid variations in intensity, which succession of intensities fuses into a new impression. The observer, therefore, hears, in addition to the two fundamental tones, an alternate rising and falling in the loudness of the sound, which fluctuation is known as beats. If these beats are slow enough to be distinctly

apprehended, they will be recognized as quite distinct from the tones. If, on the other hand, they become too numerous to be separately apprehended, they may sometimes be heard as an additional tone, when they are designated as difference tones. For example, if two tones, *c* and *g*, are sounded together, these tones having vibrations at the rates of 256 and 384 vibra-

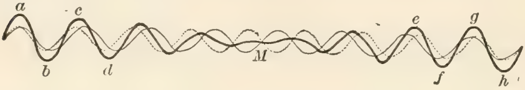

FIG. 31. Diagram to represent the formation of beats. The two curves represented by the light line and the dotted line begin together, showing the same phase at the same time. The wave motion represented by the dotted line is somewhat more rapid than that represented by the full line; consequently, the relation of the two waves changes so that in the region *M* the two are in opposite phases. The heavy line indicates the results of the combination of the two waves. *a, b, c, d, e, f, g, h* indicate the strong curve which results from the reënforcing influence of the two wave motions. *M* indicates the result of the counteracting influence of the two. From Ebbinghaus.

tions per second, the result will be a complex, in which both *c* and *g* will be distinctly heard; but there will also be heard a third tone, the number of vibrations of which equals the difference between the number of vibrations of *c* and *g*. That is, the difference tone in this case will be a tone of 128 vibrations per second.

Summation tones.

Again, there are complexities in the tonal experience such that often tones are heard in a tonal complex which, in number of vibrations, are equal to the sum of the two fundamentals. Such tones are known as summation tones. They do not seem to be purely physical facts, explicable in terms of the physical effect upon the air particles, for they cannot, in all cases, be reënforced by physical resonators (the apparatus which is commonly used in the detection of single tones in tonal complexes). Summation tones seem rather to be due to certain physiological processes, perhaps to interferences of the vibration processes in the basilar mem-

brane, or to secondary vibrations in the bony walls of the cochlea. For the ordinary observer, difference tones and summation tones play no important part in the combinations of sounds, but the result of these tones upon harmonies and discords in music is a matter of some importance, and one which has been made the subject of careful examination.

Harmony not a matter of sensation. By these discussions of tonal sensations and their combinations, we have been led to the point where it would be appropriate to take up the matter of harmony. Certain tones, when sounded together, give the observer an experience which is not merely that of tones sounding together, but is also an experience of the smooth fitting together of these tones, while other combinations give the observer a distinct impression of jar or discord. The effort has often been made to explain harmony and discord as due to certain simple processes in the organ of sense. We shall dismiss the matter for the present in a somewhat dogmatic fashion by saying that such explanations of harmony, by processes of a purely sensory type, are not satisfactory. The matter will come up later, and evidence will be presented to justify the dogmatic position here assumed.

Absence of after-images in auditory sensations. Before closing the discussion of tonal sensations, it should be noted that the nature of the auditory sensory process is such that contrast and after-effects do not appear to any great extent in tonal or noise sensations. The process in the nerve cells terminates as soon as the external vibration ceases. This characteristic of sound sensations explains why it is that these sensations can be used in musical compositions. A succession of colors, given in anything like the same relation as a succession of tones in music, would produce a hazy blur of after-effects, rather than the clear-cut melodies which arise from a succession of tones.

Tone-deafness. Certain cases of tonal-deafness, or inability to receive certain tones, have been described. A person capable of the usual tonal discriminations in many parts of the scale is quite unable to distinguish tones in a certain limited part of the scale, or at one end of the scale. This deficiency is undoubtedly related to some lack of

normal functioning in a given region of the basilar membrane, or organ of Corti. A person may also show increasing deficiency in ability to hear very high tones in old age.

Summary.

Without attempting to summarize all that has been said in the discussions of tonal sensations, it may be advantageous to prepare a table which may be used for the purposes of comparison with the earlier tables referring to visual sensations.

Physical Vibration	Physiological Process	Sensation
Series of air vibrations below 10 per second	No physiological excitation	No sensation
Continuous series of changes in rate of air vibration from 32 per second to 30,000 or 40,000 per second	A very large number of different processes in the basilar membrane and organ of Corti; the number being, however, less than the number of physical processes	Large number of sensations ranging in series from lowest to highest pitch
Same as above	More limited number of physiological processes because of incomplete development of the organ of Corti	Partial tone-deafness
Complex vibrations	Separate physiological process for each component of the complex	Recognizable complex of tonal sensations
Complex vibrations	Interference of vibration in the physiological organs	Summation tones not paralleled by objective vibrations

C. Sensations of Taste and Smell

Taste and smell differentiations of a primitive chemical sense.

Sensations of taste and smell may be considered together. Indeed, in the primitive forms of animal life, taste and smell constitute a single chemical sense. Of the two, the sense of smell is distinctly later in its development, appearing as an important separate sense with the appearance of the air-breathing animals.

In point of structure, the sense of smell shows its character as a supplementary sense by the fact that it has a structure which is much simpler in character than that of the organ of taste. It will be proper, therefore, to begin the discussion by referring first to the simpler organ of smell.

Position of olfactory organ in the nasal cavity.

It is unnecessary here for us to consider at any great length the nasal cavities, in which the olfactory cells are situated. These cavities are not true accessories to the organ of sense, as were the cavities in the ear. The organ of sense is rather accessory to the general organ of respiration. The position of the sensory cells is such that they are not in the direct path of the great volume of air which is used in the process of respiration. Figure 32 shows the area within the nasal cavity which is covered by olfactory cells. The arrow *A* in the figure indicates the path of the air current in ordinary respiration. It will be noted that in such ordinary respiration very little of the air is carried up into the upper part of the nasal cavity, and thus brought into contact with the sensitive cells. If, for any reason, it is desirable that the sensitive cells should receive the full current of air which enters the nose, the animal must sniff the air forcibly into the nasal cavity, in which case it will follow the direction of the arrow *B* in the figure, and the cells will be more vigorously affected by any substances brought in by the air currents.

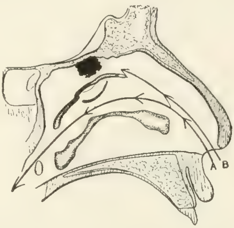

Fig. 32. The inner cavity of the nose is represented. The arrow *A* indicates the path of the air in ordinary respiration, *B* indicates the path of the air when the animal sniffs. The olfactory region is indicated by the black area in the upper part of the cavity.

The olfactory surface itself is made up of two kinds of cells, as shown in Figs. 33 and 34. There are, first,

Structure and function of the olfactory surface.

certain supporting cells which line the nasal cavity; and second, there are distributed among the supporting cells true sensory cells, from which fibers pass inward to the central nervous system. The nerve cells in this organ are directly at the surface, in such a position that particles brought in through the air currents come into direct contact with the cell body proper. This direct exposure of the nerve cells to stimulation is undoubtedly related to the fact that these cells are very easily fatigued. It is a well-recognized fact that an odor which is very striking at first soon grows less and less impressive, even though the stimulus may continue in its original intensity. Furthermore, the olfactory cells do not seem to be very definitely specialized, and there are no selective organs between the external stimulus and the sensory organs which determine the effect of stimulus on the nervous organs. There is, accordingly, no clearly defined limit to the number and variety of olfactory sensations. By way of contrast with the visual organ, for example, there is, in the case of the olfactory sense, nothing which corresponds to the rods or cones and operates to reduce all external stimulations to a limited number of sensory processes. Consequently, the number of olfactory sensations is very large, and the effort to classify them is baffled by the variety of the excitation processes and resulting experiences.

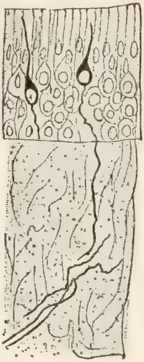

FIG. 33. Section showing the different cells which compose the mucous lining of the nose in the olfactory region. By the staining process, the special sensory cells are clearly distinguished from the other cells as black. In one of these cells the nerve fiber will be seen passing directly out of the cell toward the central organ.

External odors.

With regard to the character of the external stimuli which affect the cells of the olfactory surface, our knowledge is somewhat limited. Small particles probably detach themselves from external objects and are carried by the air currents during inspiration into the nasal cavity. These small particles, or effluvia, produce a chemical effect upon the olfactory cells. In general, it seems to be true that those substances which are most frequently brought into contact with the olfactory surface produce the least effect, whereas new and unfamiliar substances produce a strong effect. The relation between the external effluvia and the olfactory processes is probably the outgrowth of the long evolutionary process, in which the sense has developed as its chief function the ability to warn animals of the presence of unfamiliar substances in the atmosphere. Noxious gases are, from the nature of the case, relatively uncommon, and the olfactory sense, in serving to warn us of their presence, not only shows its adaptation to the stimuli which are unusual, but shows, also, the significance of the whole development as aimed at the preservation of the organism.

FIG. 34. Olfactory cells and supporting cells much magnified. The supporting cells are here shown to be larger than the true sensory cell and somewhat different in form.

Smell a rudimentary sense in man.

Animals make much larger use of the sense of smell than do human beings. They often take advantage of the presence of strange effluvia in the atmosphere and react positively to these odors, seeking the source of the odor, if it leads them, for example, to food. It is to be said in this connection that the human sense of smell can be much more highly cultivated than is commonly the case, if attention is directed to these sensations in early life.

Turning from smell to taste, we notice first that the qualities of taste sensation are more easily reduced to a classified list. The qualities most constantly recur-

Taste qualities specialized and traceable to specialized structures in the organ of sense.

ring are bitter, sweet, sour, and saline. If we add to the list alkaline and metallic, which may be compounds, it is possible to classify all taste experiences as belonging under the one or the other of the six classes, or as compounds of these. This reduction of all tastes to a few qualities leads one to look for structures in the organ of taste which shall explain the reduction of the physical manifold to a small number of sensory qualities. The study of the organs of taste shows that they are specialized structures, probably of a selective character.

Fig. 35. The depression between two sides of a papilla of the tongue. Liquids may pass down into this opening. On its sides are taste-bulbs. Their number and distribution is indicated in the figure.

Organs of taste and their functions.

The taste organs are distributed throughout the mouth and throat. They appear in greatest abundance on the papillæ of the tongue. Figure 35 shows a magnified section through the side of one of the large papillæ. At certain points in the walls of the papilla, there can be distinguished groups of cells clustered in bulb-shaped organs. These are known as the taste-bulbs. Each bulb is made up of a number of cells grouped about its wall, and constituting a minute pear-shaped organ (Fig. 36). Among these cells in the bulb are distributed tactual nerve fibers and special taste fibers, which come from nerve cells located in the immediate vicinity of the medulla (Fig. 37). The cells of the taste-bulb are chemically affected by certain fluids which act upon them, and the

chemical processes set up within the peripheral cells are transmitted first to the nerve fibers, and through these to the nerve cells, and, finally, from the receiving nerve cells to the central nervous system. Probably not all the cells in the taste-bulbs act equally in receiving taste stimulations. Some of the cells in the bulbs seem to be specialized for the taste function, while others play the part of supporting cells. The peripheral organs are not true nerve cells, as were the receiving cells in the olfactory organs; they are intermediate between the sensory fibers and the outer world. Their function is, undoubtedly, selective. This accounts for the more definite and independent character of the taste qualities, in comparison with odors. The selective character of the taste cells is strikingly shown by the fact that not all taste-bulbs receive with equal facility the various taste stimulations. Thus, the cells in the back part of the tongue are much more sensitive to stimulation from bitter substances. Cells in the front part of the tongue respond more readily to sweet solutions. On the sides of the tongue, the areas are especially sensitive to sour and saline stimulations. To be sure, the localization is not absolute, especially for

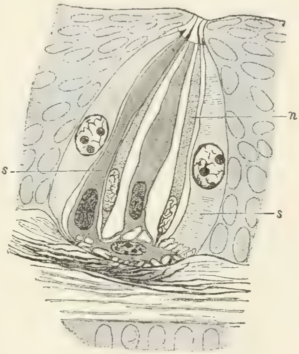

FIG. 36. A diagrammatic section of a single taste-bulb to show the character of the different cells. The cells marked *n* are the special sensory cells. The cells marked *ss* are supporting cells. It will be noticed that the cells constituting the bulb are somewhat larger than those which form the general surrounding tissue.

sour and saline, but it is very far in advance of anything found in the olfactory surface.

External stimuli for taste.

The substances which act upon these taste-bulbs must be in liquid form. If one dries the tongue thoroughly, the substances which would otherwise produce taste impressions can be pressed against the tongue without producing any effect. For example, a piece of dry salt placed upon the dry surface of the tongue will not give rise to any taste sensation.

FIG. 37. A diagrammatic sketch showing two neighboring taste-bulbs. The supporting cells have been removed in the two bulbs. The bulb on the right has four specialized gustatory cells. The network of fibers at the base of these cells shows the mode of distribution of the gustatory nerve fibers. In the bulb on the left and in the intermediate tissue between the bulbs, the terminations of the tactile nerve fiber are shown. The tongue is thus seen to be an organ of touch as well as of taste.

D. Sensations of Touch

Organs of touch the primitive type of sensory surface.

The group of sensations popularly classified under the sense of touch might very properly have been considered at the beginning of this chapter, for touch is the human sense which is most closely allied in character and in the structure of its organs to the primitive senses of the lower animals. Indeed, the surface of the body is a relatively undifferentiated mass of protective and sensory cells, which are open to stimulations of all kinds and capable of responding in some degree to almost any form of external energy. The true nerve cells for the sense of touch are situated in the immediate neighborhood of the spinal cord. They are primitive bipolar cells, as shown in Figs. 12 and 13, pages 41

and 42. The branch which passes out of one of these bipolar cells toward the surface of the body is the receiving sensory fiber. When it reaches the skin, it breaks up into a fine network of fibrils. These fibrils are distributed among the cells of the skin. The arm, from the same cell which extends into the spinal cord, has been described in the discussion of the spinal cord. It will be recalled that this central arm branches so as to extend upward and downward through a large section of the spinal cord, sending out at various levels collateral branches which transmit the stimulation to the motor cells at the different levels of the cord or carry the stimulation to the higher nervous centers.

Differentiation of the tactual fibers. Temperature spots.

The sensory fibers which pass to various parts of the surface of the body seem to be differentiated in their functions to some extent in spite of the uniformity of their structure. For, while it is probably true that there is no region on the surface of the body which is not susceptible to stimulation in some degree by all forms of external energy, provided the energy is strong enough, yet it is certain that there are regions capable of responding easily to slight changes in pressure and temperature. Indeed, there are areas which show special susceptibility to pressure, and others especially sensitive to temperature. The specialized areas are usually points or, at most, limited areas. The most striking illustration of this differentiation of the skin can be secured by taking a metallic point which has been reduced somewhat in temperature, and passing this point slowly across the skin. At intervals the point will be recognized as distinctly cold, while on other parts of the skin it will be recognized merely as an external pressure without temperature quality. Those areas where the point is recognized as distinctly cold have been designated cold spots. It may be that the effect is due to modifications in the thickness of the skin or to the proximity of blood vessels, or to the grouping of nerve fibers about a hair follicle; or it may be that there are differences in the skin cells among which the nerve fibers are distributed, which differences in the skin cells account for these special functions.

Pressure spots.

A second type of specialized points on the surface of the skin includes those points which are specially susceptible to stimulations of pressure. If one applies a fine hair to points on the skin, it will be found that there are certain points at which the pressure will be recognized, while there are other points from which no sensation will arise. Those points which respond to the slightest stimulation are called pressure spots. The number of pressure spots discovered in any special region will depend, of course, upon the intensity of the pressure exerted by the hair, so that the term pressure spot is a relative term, and depends for its exact definition upon the intensity of the stimulus applied to the skin.

Other "spots."

Heat spots and pain spots can also be found. The heat spots are much more diffuse and difficult to locate than the cold spots, but they are analogous to the cold spots in their response to changes in temperature stimulation. Pain spots appear in certain parts of the body and may, perhaps, be defined as specially sensitive pressure spots. Whole areas of the body surface, as, for example, the cornea of the eye, are so sensitive that any stimulation which is recognized at all, will be recognized with the quality of pain rather than that of simple pressure. There are certain reasons for treating pain as distinct from pressure.

Relativity of temperature sense. Chemical and mechanical senses.

One characteristic of the temperature spots is their change in sensitivity when stimulated for a period of time by any given temperature. For example, the hand which has grown cold from a long exposure to cold air will react to water of a moderate degree of temperature in such a way as to give rise to the sensation of warmth, while the same hand, after it has been exposed to warm air, will give sensations of cold from the same water. This relativity, as it is called, of the temperature sense is due to the fact that the nervous processes involved are chemical processes which, when once established, change the condition of the sensory organs so that the reception of later stimulations depends upon both the present stimulation and the condition induced by past stimulations. Similar facts

have been noted in the discussion of color contrasts and olfactory fatigue. There is no marked relativity in the case of sensory processes of hearing or of pressure. There is a basis in these differences with regard to relativity for a distinction between the chemical senses on the one hand, including the temperature sense, the senses of smell, taste, and vision, and the mechanical senses on the other hand, including those which depend upon direct excitation of the nerve fibers; namely, pressure and hearing. The chemical senses show greater relativity and more striking after-effects than do the mechanical senses.

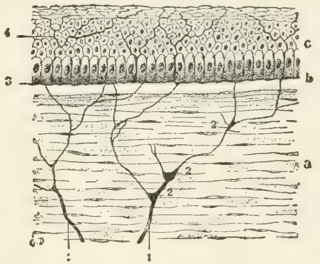

Fig. 38 *A*. Tactual end organs.
A section of the cornea of the eye much magnified. The small cells in the upper part of the figure show that the tissue is made up of a number of small, compactly arranged cells. A nerve fiber is seen distributing its branches among these cells. This is a typical form of distribution of the tactual fiber, which ends freely in the surface of the body. After Testute.

Organs of touch at the periphery.

The peripheral endings of tactual fibers are in some cases surrounded by special structures; in other cases the fibers end freely among the cells of the skin. A number of typical end organs are shown in Figs. 38–41. Some evidence has been accumulated to show that the differentiated qualities of tactual sensation are related to these specialized structures. Thus, there are certain organs which appear in the conjunctiva where there is no sensitivity for pressure, but where there is sensitivity for cold. This leads to the inference that they are special organs for cold. Again, certain tactual cells seem to be especially numerous in regions sensitive to pain. Pain, however, is the only type of

sensation from certain other regions where the fibers end freely among the epithelial cells. The evidence is, therefore, not conclusive that the end organs in the skin are specialized; they may be primarily protective organs.

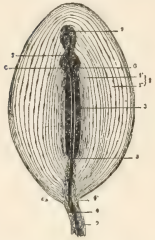

Fig. 38 *B*. A Pacinian corpuscle. After Testute.

Muscle sensations and organic sensations.

Sensations from the inner organs of the body have sometimes been classified under the tactual sense; sometimes they have been regarded as constituting separate classes. All the inner organs of the body have sensory nerve fibers similar to the tactual fibers which end in the skin. Thus, the muscles, joints, linings of the organs of the thoracic, and especially of the abdominal, regions, are all supplied with sensory nerves. In discussing the experiences received from the limbs, it is sometimes convenient to distinguish under the name muscle sensations the experiences resulting from the excitation of the sensory fibers ending in the muscles. In like manner, sensations from the abdominal organs are sometimes classified as organic sensations. The motives for minute analysis of these sensations from the inner organs are not strong, because these sensations are relatively undifferentiated. In the normal course of life they come into experience with a great mass of skin sensations, and they never are intense except when they are abnormal.

Fig. 38 *C*. A Missenian corpuscle. After Testute.

Fig. 39. Shows two Golgi-Mazzoni corpuscles of the type found by Ruffini in the cutaneous connective tissue of the human finger.

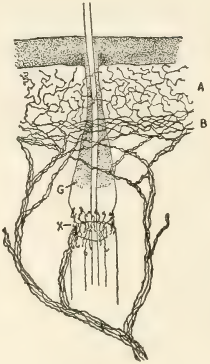

Fig. 40. Shows the complex distribution of a tactual nerve fiber in the immediate vicinity of a hair. The freely ending nerve fibers in the region *A* directly under the epidermis is to be compared with the freely ending nerve fibers shown in Fig. 38 *A*. These fibers before their distribution in the area *A* form a network in the cutis in the area *B*. Around the shaft of the hair are certain glandular tissues marked *G* in the figure. Branches from the general nerve trunk are distributed, as indicated at *X*, about the hair and its surrounding tissues. The figure is from Retzius.

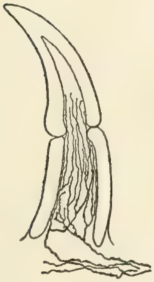

Fig. 41. Tooth of Gobinus showing the distribution of the nerve fiber inside the tooth. After Retzius.

E. Sensation Intensities

Intensity a general characteristic.

While it has been necessary to discuss sensation qualities in terms of the relation of these qualities to various organs of sense and various forms of external energy, it is possible to treat the matter of sensation intensities in a somewhat more general way. The relation of changes in the intensity of objective sounds to changes in the intensity of sound sensations is of essentially the same type as the relation between the intensity of pressure stimuli and pressure sensations. Indeed, it is in this sphere of sensation intensities that the general methods of modern experimental investigation were first most fully developed. The early experimental investigators had the largest confidence that they would be able to develop general mathematical formulas which would define the relations between external stimuli and sensation intensity with a degree of comprehensiveness and precision comparable to that which is attained in the physical sciences. As a result, they performed the most laborious experiments, and collected a mass of data which is not equaled in quantity by the data relating to any other single sphere of psychological phenomena.

Weber's Law.

The general principle which was established by these investigators is commonly known as Weber's Law. This law states that the increase in sensation intensity does not follow directly the increase in the physical stimulus. While the physical stimulus is increasing either continuously or by additions of small increments, the sensation increases in recognizable intensity only after there has been a certain percentage of increase in the intensity of the external stimulus. To make the matter concrete, if a certain intensity of light is continuously increased or is increased step by step by small additional amounts of energy, there may result in subjective experience no appreciable increase whatsoever. Before a change in the intensity of the sensation can arise, the external light must be increased by about $\frac{1}{100}$ of its original intensity. Various investigators have found somewhat different fractions ranging from

$\frac{1}{186}$ or $\frac{1}{167}$ to $\frac{1}{57}$, but in any case when the fraction is determined for a given intensity of light, say one hundred candlemeters, the same fraction holds, at least approximately, for all other medium intensities. The meaning of Weber's Law can be made clear by considering the following negative illustration. If we add to a single candle the small quantity of light necessary to increase it by $\frac{1}{100}$, an observer will be able to recognize the change. If, now, we add to a light of one thousand candlepowers the same $\frac{1}{100}$ of a single candlepower, the effect will be absolutely unappreciable; that is, the sensation will not be modified at all. Ten candlepowers must be added to one thousand before an appreciable change takes place in the observer's experience.

General statement of the law.

The law holds in general for all spheres of sensation intensity. The ratio of increase in the different spheres of sensation differs. Thus, while it is $\frac{1}{100}$ for light, it is given by Wundt as $\frac{8}{100}$ for pressure. Other fractions are reported for other spheres of sensation. In general, however, the relation is always of the same type. It has been expressed briefly in the statement, if the sensation is to increase in an arithmetical ratio, the stimulus must increase in a geometrical ratio. The range of applicability of this general principle is limited in each case to stimuli of moderate intensities.

Mechanical explanation of Weber's Law.

After the law has been established as a statement of an empirical fact, it is by no means easy to determine its value for the explanation of mental life. It probably expresses a law of nervous behavior which is a special case under the general mechanical principle, that any increase in any form of physical activity becomes more and more difficult as this activity reaches a higher level of intensity. For example, it is extremely difficult to add to the speed of a locomotive beyond a certain point. If the locomotive is moving at the rate of fifteen miles an hour, a moderate increase in the amount of energy applied to the machinery will increase the speed by a mile an hour. If, however, the engine is moving at the rate of sixty miles an hour, the amount of energy which must be expended to add one

mile to its speed is very much greater than the amount which was necessary to add this same increment of speed when the engine was moving at the rate of fifteen miles. This mechanical principle is applicable to the action of the nervous system. If the external stimulus acting upon the sense organs is producing a certain moderate degree of chemical activity, that chemical activity can be intensified by a small addition to the external stimulus. If, however, the stimulus acting upon the nerve cells is so strong that it demands nearly all of the energy that the cell is capable of giving out, then the same addition to the stimulus will produce no effect. Since this is a general principle of all nervous behavior, it is a principle which appears alike in all the different spheres of sensation.

Other views regarding Weber's Law.

Other interpretations of Weber's Law have been given in the history of psychology. One such interpretation, given by Fechner, was of a most ambitious type and was intended by its author to express in exact mathematical terms the general relation between mind and matter. The significant fact which Fechner was emphasizing, that the relation between consciousness and the physical world is not direct, is abundantly established by considerations of a more general character than those which Fechner took up. We have seen in our earlier discussions of sensation qualities that there are many other phases of experience which do not parallel the physical facts with which they are related. The importance of Weber's Law as a demonstration of the indirectness of the relation in question is, therefore, relatively less now than it was in the time of Fechner. The definite mathematical formulas are of relatively little value. The whole study of sensation intensities was, indeed, more productive for general psychology in the experimental methods which it served to cultivate than in the contribution which it made to the content of psychology. The discussion of sensation intensities may, accordingly, be dismissed without further detail. When the methods of experimental investigation appropriate to this subject were once fully developed, they led on to more fruitful problems and more productive results.

CHAPTER VI

SENSATIONS AND THEIR FUNCTIONAL RELATIONS

Sensation qualities are to be distinguished from the uses to which sensations are put in experience.

THERE is some danger that the student who approaches mental processes through a study of sensations will make the mistake of assuming that sensations are the same type of facts for ordinary experience and for scientific description. A moment's consideration will correct this mistake if it exists. For example, the color sensations which come to the eye from two neighboring shades of red in a painting may be distinguishable as sensation qualities if they are scientifically considered, but they may not be discriminated at all in the experience of a given observer. Even if the observer is conscious of a difference, his consciousness need not always take the form of a recognition of difference in color quality. It may be that the artist has used the darker tone to suggest distance, and the observer may accept the suggestion and distinguish only differences in apparent depth, not being at all aware of differences in color quality.

Sensations perform their functions through the relations into which they enter.

Such an example as this serves to illustrate a distinction which is important for psychology; namely, the distinction between a sensation and its function. A sensation is a qualitative element of experience conditioned by the stimulation of some organ of sense. The function of a sensation can be defined only by considering the use to which the sensation is put. Thus, red may serve under certain conditions the purpose of warning an observer of danger or under other conditions of calling his attention to ripe fruit. It is no less a sensation because it serves these various ends, nor, on the other hand, can the end served be identified with the sensation quality. The function which a given sensation serves is not determined merely by

the quality or intensity of the sensation; it is determined in large measure by the relation into which the sensation enters. Thus, the sound made in articulating the word "eye" serves one function when it is used in connection with the description of the organs of sense and an entirely different function when it is used as the first personal pronoun. The relations of the sound determine the value of the sound for practical experience. We must, therefore, consider the relations into which sensations enter if we would have a complete account of experience. These relations are just as much a part of experience as the sensation qualities. The student of science, who begins his study by concentrating attention upon a sensation taken so far as possible out of its relations, and for the moment considers all sensation qualities as fixed and uniform in value and distinctness, must recognize that the elements of mental life never are in reality fixed and uniform; in reality, they enter into all manner of productive relations. Red may be considered for certain purposes of science as a fixed quality, but it is in reality always a center for some moving relations.

The scientific element of experience is not the point of departure in mental development.

Another way of illustrating the distinction between sensations and sensation functions is to inquire, What is a simple mental process? For the psychologist a sensation considered out of its relation is a simple unit with which he can conveniently work in reconstructing and explaining experiences. From the point of view of ordinary experience, it requires much mental development to be able to concentrate attention upon the scientific unit or elementary factor in a mental process. The simplest mental process from the point of view of mental development is the kind of an experience which a child or an animal has, and this is not an experience of a discriminated sensation quality.

Element of movement contrasted with simple movement.

An analogy will help to make this clear. Considered scientifically, the movement of a single finger is a simple element of the more general movement executed in closing the hand; but considered from the point of view of development, the separate movement of a single finger can be attained only as the result of long

practice, as every one knows who has tried to bend a single finger while keeping the other parts of the hand perfectly still.

The discovery of a sensation quality is dependent on a high form of attention.

In like manner, we find that concentration of attention upon a single point in the field of vision is always a special, highly developed effort of attention, in contrast to the general survey of the whole visual field. The general survey, though it involves more factors, is the easier and decidedly earlier form of visual observation. Finally, the concentration of attention upon the mere color quality of a visual point is a distinctly more difficult task than concentration on all the attributes of such a point, that is, upon its position, color, and meaning, without any attempt to select one attribute to the exclusion of the others.

Elements and relations approached from different points of view.

We may sum up the discussion of this distinction between a sensation and its functional relations by stating that an observer always begins in his experience with a great body of sensations in their relations and arrives at the single sensation factor only by an effort of analytical attention. Science, on the contrary, finds it simpler to consider first the sensations out of their relations, and afterward to take up one by one the typical relations into which the sensations may enter.

Sense perception is a complex of related sensations.

Our problem as thus defined is perfectly clear. After the description of sensations and their conditions comes the study of the relations into which sensations enter. This problem may be defined by introducing a technical term used in all psychological literature; namely, the term sense perception. Whenever one opens his eyes and sees an object, he has visual sensations in their functional relation; he has what is known as a visual percept. When he hears and recognizes sounds, he has an auditory percept; when he touches an object with his hand, he has a tactual percept; when he receives experiences through several senses at once, he has a percept made up of a complex of sensory factors. The laws which govern the process of perception cannot be defined merely by referring to the laws of sensation; there must be a consideration of the laws of

relation between sensations. A percept is a complex of interrelated sensations. This chapter has to deal, accordingly, with the laws of interrelation between sensations.

Functional relation of sensations to motor processes.

Our problem is not exhausted, however, when we have dealt with the interrelation between sensations, for every sensation is related in some way to the active processes of expression. This statement finds support in any consideration of the physiological structures which are involved in the reception and combination of sensory processes. Thus, in all our study of the nervous system and its development, we found that the central organs of the nervous system receive stimulations, not for the purpose of merely absorbing the energy which these stimulations bring to them, but rather for the purpose of transmitting the energy, after redistributing and reorganizing it, to the motor system. A sensory excitation is, therefore, always related to some motor process. The motor process is in an important sense the end toward which the sensory process is aiming. No consideration of the functional relation of the sensory process will be complete without reference to motor ends.

Fusion and attitude defined.

It will be necessary to use certain terms to distinguish the two types of relations described in the foregoing paragraphs. For the relation between sensory qualities the term fusion will be used. Thus, when a book is perceived as made up of white paper and black printing and brown binding, it is said to be recognized through a fusion of the sensations, white, black, and brown. Fusion does not signify here that the elements change their respective characters, but that they unite in close relations in a single larger process, the process of perception. For the relation of sensations to activities the term expressional relation or the term attitude will be used. Thus, when a sensation of pain issues in an exclamation, the significance and value of the pain can be described only by considering that it arouses a system of organized motor tracts which lead to the expressive activity mentioned. The expression itself is the final stage of the process, but it involves a series of

relations which can conveniently be referred to by the single term attitude.

For the purposes of scientific study, it will be advantageous to consider fusions and attitudes in different chapters, as if they were separable phases of the problem of functional relation. It should, however, be explicitly understood that this subdivision of the problem does not imply that in practical experience fusions take place without expressions. We shall take up fusions first, but we shall constantly be reminded that the modes of expression which appear in connection with all sensations are so fundamentally necessary that one may say that consciousness is characterized chiefly by the attitudes of which it is made up, sensation serving merely to initiate these attitudes. So close will the relation between fusion and expression appear that we shall find the explanation of one always involving the other. With this warning against the error of assuming that fusion and expression are unrelated, we turn first to a consideration of fusion.

Fusion and expressions everywhere related.

By way of concrete illustration let us assume that a person is listening to a speaker whose facial expression he is also watching. Any single word which the speaker utters will be recognized by the listener, not merely as a sound, but also as a significant experience with a broader meaning attached to it. The listener brings together in his perception of the whole situation all of the auditory and visual factors which attend the hearing of the sound, and also memory factors derived from his past acquaintance with the speaker and his past knowledge of the word. Memory factors will not be dealt with in the first study of sensation fusions, it is enough for our present purposes to call attention to the fact that the listener's recognition of the speaker and his words is a composite, and at the same time unitary, experience.

Fusion illustrated.

Certain leading characteristics of such a fusion are so obvious that they will be recognized as soon as stated. Thus, it will be recognized that the visual and auditory sensation factors which enter into the experience are not first considered as separate phases of experience

Perceptual fusion an immediate process.

and then voluntarily combined with each other by an additional process of thought. The total mass of sensory experience present at the moment is combined by the listener into a single act of perceptual recognition and interpretation, and this single act is quite as immediate for consciousness as the reception of the sensations themselves. If one considers the way in which such a fusion process has developed, he will see that there is no justification for treating fusion as an act of experience subsequent to the reception of sensations. When the observer first began in his earliest childhood or in any novel experience of adult life to look and listen, he had in consciousness a mass of experience which included, not only the visual and auditory sensations from the speaker, but also the sensations from the background surrounding the speaker, the tactual sensations from the observer's immediate environment, and all the organic sensations from within the observer's body. In short, the presence in consciousness of a great mass of sensations is the first stage of all perception. At this stage the single sensations may be said to stand in a vague, indefinite, functional relation to all that is in consciousness. As experience becomes more definite, the relation between certain of the sensation factors becomes closer and more fixed, while other relations are neglected and the unimportant sensory factors become vague. The fusion of the sensations derived from a clearly recognized speaker must be considered, accordingly, as a narrowing down of experience from an original, loosely organized complex, to the particular group of factors which it is now significant to hold together, rather than a forcing together of factors foreign to each other. We shall have occasion later to refer to the fact that analysis is always present in perception. It is enough here that it be recognized with all clearness that fusion is not a late and unique fact of binding together the sensation factors which were originally separate. It is rather true from the very first that absolutely no sensation is capable of presenting itself in consciousness without some functional relations, and the term fusion is merely

a term for these functional relations. Sensations are never isolated factors in mental life; they are immediately fused with each other.

The problem of perceptual forms.

Since fusion of some kind is always present in experience, the question which arises for scientific study is the question of the various types of fusion. When we pass from a vague mass of sensory factors loosely united, to a definite and well-organized percept of some single object, what are the various types and stages of perceptual analysis and fusion? The problem may be stated somewhat differently by asking, What are the forms of arrangement which develop in perceptual consciousness?

Space, unity of objects, and time.

In answer to this question we shall find that the first and most clearly definable form of fusion is that which we know as space. A second form of fusion, which it is less easy to define by a single term, may be designated the unity of individual objects in experience. Finally, there is a third form of experience which is very commonly regarded as analogous to space, but which depends, as will appear later, upon more general characteristics of sensations and has a more universal application to all of the phases of mental life than has space. This more universal form of experience is time. Again, let it be stated explicitly that in referring to these forms of experience as if they were separate phases of experience, we are simply following the path of least resistance in our psychological discussion. It is easier to study space and unity and time, as if they existed apart from each other, rather than constantly to refer to the fact that no group of sensations is ever organized in space without being also organized in time and in the form of separate objects of experience. With this general statement as to the grounds for considering separately the forms of sensory fusions, we turn first to the consideration of space.

I. SPACE

A. Tactual Space

One of the earliest experimental studies in space perception dealt with the spatial arrangement of tactual

Simple tactual discrimination of points.

experiences. In his effort to find some method of testing the sensitivity of the skin, Weber measured the distances which must lie between two stimulated points on the skin in different parts of the body in order that the points may be recognized as separate. He found that in much-used regions, such as the ends of the fingers, the lips, and tongue, the distances which can be recognized are very small, often less than a single millimeter; while on the upper arm or the middle of the back the points must be separated by three to six centimeters in order to be recognized as two. Furthermore, as has been abundantly shown since the time of Weber, there is the greatest uncertainty in the estimation of distances and directions in the regions where the distances are large.

Subjective recognition of space differs from the objective space of the geometrician.

On the basis of these facts we may emphasize the difference between external space and our recognition of space. Two millimeters of extension on the middle of the back are for the geometrician equivalent in all respects to the same distance on the finger. For the observer who perceives these two regions through the sense of touch, the recognition of the two distances is not a geometrical fact, uniform for all parts of the body, but a complex of experience. He must have sensations, and these sensations must be discriminated and arranged in some relation to each other; that is, they must be organized into a percept or complex of sensations. The sensation factors have been accounted for in our earlier discussions. The conscious discrimination and arrangement of sensory factors in the spatial form involves more than the mere reception of sensations.

Sensation and perception can be distinguished.

Experiments of the kind which Weber tried can be carried farther. Thus, it has been shown that after a little training regions of the skin where the discrimination was relatively difficult can be developed so as to permit of very much finer discrimination than that which was exhibited at first. In other words, without any radical change in the sensory conditions, practice will rapidly refine space perception. Again, if any region of the skin is stimulated by means of a continuous

line rather than by two separate points, it will be found that the greater mass of sensations received from the line facilitates the discrimination of the sensations received from the extremities of the line. A line will, therefore, be recognized as having extension when it is about one third as long as the distance between two points which are just discriminated as separate from each other. The difficulty of discriminating two points when they are presented alone is not due to the character of the sensations from the points, but rather to the difficulty of discriminating them without the aid of a more complete sensory series with which to make up the percept.

Difficulty of analyzing perceptual complexes.

The discussion thus far makes it perfectly clear that the recognition of distances on the skin is a complex process, but the observations reported do not make equally clear what elements enter into the complex. In fact, the analysis of such an experience into its elements is extremely difficult, because the sensation elements are not significant as separate facts, and consequently, it is not easy to concentrate attention upon them as distinguished factors. Our analysis must, accordingly, be indirect, beginning with certain general studies of the process of perception.

Development of spatial arrangements in the course of individual experience.

In our search for an explanation of the facts of tactual perception of space, let us ask what is the course of individual development. Any one who observes an infant recognizes that early in life there is the greatest uncertainty in locating stimulations on the skin. If the skin of an infant is vigorously stimulated either by some accident or by the efforts of some one who is interested in making an experimental investigation, it will be found that the infant moves its hands about in the most indefinite fashion, often failing entirely to reach the irritated spot. We can understand the infant's difficulty if we try to locate with precision some point which has been stimulated on the skin of the upper arm. The infant has sensation enough, just as we have when stimulated in an undeveloped region, but the sensation is not properly related to other sensations. It has no recognized relations which give

it an individual place in a well-ordered sequence of tactual or visual qualities, because the well-ordered sequence has not yet been built up. An established series of relations of some definite kind is necessary before the sensation can enter into distinct percepts. Until a definite relation is developed, the sensation will enter only into vague fusions, and localization will be altogether incomplete. The change from vague to definite localization requires much experience and attention. Indeed, it is a fact easily verified that no sensation becomes definite in its relations until the practical needs of life demand such definiteness. The reason why an adult discriminates points on the end of the finger and not those on his back, is that in the course of life he has been obliged to use his finger sensations. Use has led to an arrangement of points, to the development of what may figuratively be called a map. This process of developing definiteness in tactual localization has undoubtedly been very greatly facilitated by the presence of vision. Even in adult life one can often find himself making his experience of a tactual stimulation more exact and complete by looking at the point irritated, thus relating the tactual sensation to visual sensations. The process of localization of tactual sensations is also very largely dependent on movement. It is an empirical fact that the perceptual arrangement of skin sensations is most complete in the most mobile parts of the body. A number of careful experimental observers at one time explored the whole surface of the skin and showed that in any given region that part which is most mobile is the part on which points are most easily discriminated. Thus, the hand is the most highly developed part of the arm; the foot is the most highly developed part of the leg; the limbs are more highly developed than the trunk.

Tactual percepts of the blind.

In some respects the tactual perception of blind persons is more highly developed than that of persons who have vision. The blind are not supplied with better organs of sense, but they make more discriminating use of such experiences as they receive through the

skin. They also make more use of movements than do normal persons, as may be observed in the fact that they restlessly explore every object which comes within their reach. The limitations of the space perception of the blind appear when complex objects are presented for recognition. When the mass of sensory impressions is great, the discrimination and fusion of these sensations becomes very difficult. This fact is strikingly illustrated by the history of the raised letters used in books for the blind. The most natural way of producing such books, and the way which was followed at first, was to print in raised lines the same letter forms as are used for persons who read visually. For vision the complex lines of ordinary printed letters offer no difficulties, because vision is so highly organized that it discriminates easily the ordinary printed forms. No one realized that touch being so much coarser than vision would discriminate forms less easily. Such proved, however, to be the case. The letters for the blind have, accordingly, been simplified until in one of the best and most recent systems, the letters are made up entirely of points. These points are easy to distinguish, and being placed near one another are also easy to recognize in groups.

Wundt on the tactual perception of the blind.

The character of tactual perception in the case of the blind is thus illustrated and discussed by Wundt. "The way in which the blind alphabet is read shows clearly how the space ideas of the blind have developed. As a rule, the index fingers of both hands are used in blind reading. The right finger precedes and apprehends a group of points simultaneously (synthetic touch), the left finger follows somewhat more slowly and apprehends the single points successively (analytic touch). Both the synthetic and analytic impressions are united and referred to the same object. This method of procedure shows clearly that the spatial discrimination of tactual impressions is no more immediately given in this case than in the case where vision was present, but that in the case of the blind the movements by means of which the finger that is used in analytic touch passes from point to point, play the

same part as did the accompanying visual ideas in the normal cases with vision."

Lotze's local signs.

Another method of describing the tactual perception of space is that adopted by Lotze, one of the earliest of the writers on physiological psychology. Every point on the surface of the body gives rise, said Lotze, to a tactual sensation which in addition to its general quality and intensity as a tactual sensation has a peculiar and characteristic shading due to the structure of the skin at the particular point where the stimulus is applied. Thus, if the same pressure is applied to the lips and the forehead, the resulting sensations will, in spite of general likeness, be slightly different in the two cases, because there is soft muscular tissue under the skin of the lips and hard bony tissue under the skin of the forehead. These slight differences between tactual sensations which are due to locality lead the observer to arrange his tactual sensations in certain systems or series. The qualitative shadings are thus transformed into spatial series. The qualitative differences come to signify position and are consequently designated as local signs. Their character as *local* signs is derived from the spatial system to which they lead; they are individually merely qualitative differences.

Inner tactual factors.

The factors which enter into tactual space percepts are probably derived in part from the inner organs, such as the semicircular canals, the joints, and muscles. From the semicircular canals, as pointed out in an earlier chapter, there is a constant stream of excitations reaching the central nervous system with every change in the position of the body. The limbs in their movements give rise to sensations in the joints and muscles. While the child is exploring the surface of his body and attaining the degree of ability to discriminate points which is shown by Weber's experiments, he is also learning through muscle sensations to recognize distances away from the surface of his body by reaching for things about him. He is learning through the sensations from his semicircular canals that there is a fundamental distinction between "right

side up" and oblique or inverted positions. He is learning through joint sensations to recognize how many steps must be taken to cross certain stretches of space.

Space a general form of arrangement.

The striking fact is that ultimately all these different sensory factors are fused into the same space form. There is not one tactual space and another space for muscle sensations and another for joint sensations. All are fused into a single system. For this reason there is a temptation to simplify the explanation of space by assuming that the spatial form of percepts is natural to one special group of sensations and is then transferred to all other sensations. Muscle sensations have often been credited with some peculiar spatial characteristics. Or visual sensations have at times been treated as the source of space when tactual experiences are under discussion. The problem is thus evaded. Later in the discussion of visual space, the converse fallacy creeps in of assuming that visual space is explained by fully developed tactual space. The general fact must be faced from the first, that space is the result of a complex arrangement of single sensations which are, when individually considered, merely qualitative factors of experience. The spatial order is a relational fact. Whenever sensations are fused into the spatial relation they take on a character different from that which can be assigned to them when they are considered alone. Furthermore, the full nature of this spatial relation will evidently not be understood until some recognition is given to the total group of tactual, auditory, visual, and other sensations which enter into it.

General conclusion regarding tactual space.

From this survey of the facts of tactual space we have derived several important conclusions. Space is a complex including many factors. Space is not a sensation quality, but a relational form of experience. Tactual space is not explicable without reference to the general formula of organization which includes auditory and visual factors also.

We are, accordingly, justified in postponing the general explanation of space perception until we have taken up

the facts regarding the arrangement of auditory and visual sensations in the spatial form.

B. Auditory Space

Experiments with sounds.

Experiments on the localization of sounds may be made as follows: Let a sound be produced in the median plane which passes vertically through the head from in front backward, midway between the two ears. If the sound is simple in quality, as, for example, a sharp click of some kind, and the observer's eyes are closed so as to eliminate vision and make him entirely dependent on hearing, the localization of the sound will in the majority of cases be erroneous. The sound will always be localized somewhere in the median plane, but its exact position in this plane cannot be recognized. If, on the other hand, the sound is moved slightly to the right or left of the median plane, it will be found that the observer can localize the sound with great acccuracy. The explanation of these results is simple and depends chiefly upon the fact that the observer has in the different intensities of the two groups of sensations received in the two ears his chief data for the recognition of localization. From all positions in the median plane the two groups of sensations received in the two ears have equal intensities, whereas the intensities of sounds received in the two ears from any position outside of the median plane are unequal.

Perceptual fusion a product of development, not a distinct act of consciousness.

It is important to notice that no observer can recognize the two groups of sensations from the two ears as separate. When we speak of the two groups of sensations as data for localization, we do not refer to any explicit recognition of differences; we refer rather to different factors which appear in consciousness only in their functional relations. We must assume that as the observer's experience has developed, the total mass of auditory sensations has gradually been organized in such a way that equality in the two groups of sensations from the ears has come to signify position in the median plane, whereas inequality in the two groups of sensations calls out a percept of localization

on one side. To speak of the process as one of reception of the two groups of sensations and fusion of the received impressions, is undoubtedly a true scientific description of the facts; but in using this description we should constantly recognize that there is no isolation in the observer's consciousness of the factors involved, rather a gradual development of all of the factors into a single clearly arranged percept. The only sense in which we have a right to speak of discrimination in such a connection is that in which we refer to the conscious setting off of the definitely localized auditory experience from the total mass of sensations offered to the observer. Auditory localization is, accordingly, not a series of steps by which isolated sensory factors are forced together. It is rather an immediate process of arranging the world of auditory sensations in terms of the possibilities of harmonious arrangement.

Influence of movements in auditory experience of position.

Undoubtedly here, as in the case of tactual space, the facts of movement are of great significance in organizing sensory experience. If a sound on one side of the head is more intense than the sound on the other, there will be a strong tendency to readjust the head in such a way that the stronger sound shall be made even more intense and the weaker group of sensations shall be made still fainter by the movement of the head. If a sound is in the median plane and there is difficulty in getting at its precise localization, there is frequently a noticeable effort on the part of the observer to bring the head into such a position that a more satisfactory determination of position shall be possible through a modification of the intensities of the sensations from the two ears. Often auditory perception issues in a movement which tends to bring the eyes toward the source of the sound. The same tendency which was noted in the discussion of tactual sensations to fuse various kinds of sensations into a single spatial system is obvious in this effort to supplement hearing by vision.

The experiment which has been described can be made more elaborate by giving attention to qualita-

Qualitative differences in auditory sensations are used to some extent for purposes of localization.

tive differences as well as to intensive differences in the two groups of sensations received by the two ears. There can be no doubt that the external pinna of the ear modifies somewhat the character of the sound as it enters the auditory canals. If a complex sound strikes the pinna from in front, its quality will be different from that which would result if the same sound were carried into the ear from behind. As a result of these qualitative modifications produced by the external ear, we are able to localize complex sounds even in the median plane. The human voice, for example, in the median plane of the head, can usually be recognized with great precision as coming from a point in front or behind. It was for this reason that the earlier experiment in which differences in intensity were to be emphasized, employed simple, indifferent sounds which could not be easily modified in quality through the action of the external ears.

The value of qualitative differences appears when they are absent.

The significance of qualitative auditory differences for localization of sounds is very well shown in the following negative experience. If one attempts to locate the source of a high shrill sound, such as that produced by a cricket, he finds it very difficult. The tone produced by the cricket is so high in its pitch that the ordinary observer hears nothing but the fundamental tone, the overtones being quite beyond the range of the ear. The tone is, therefore, for human hearing, a perfectly simple tone, and its quality will undergo no change through resonance as it strikes the pinna from any direction. Its intensity is also so small that the difference of intensity between the sounds in the two ears will be minute. The difficulty experienced in turning the two ears so that they shall give any clear indications of the position of the source of the sound will be familiar to many observers.

Auditory localization of small importance in human life.

In human experience the ability to localize sounds is not very fully developed. Sounds are used rather as means of social communication, and qualitative differences are more important than spatial differences. There is, perhaps, some connection between this reduced emphasis on spatial organization in man and the re-

duction of the outer ear to a rudimentary and stationary organ. Many of the animals that depend upon sound to guide them in their activities are capable of modifying in a marked degree the way in which sounds enter the ear by turning their outer ears in various directions. They are thus able to increase or decrease the intensity of sounds and to modify their quality. The movement sensations thus derived from the outer ear and the resulting series of changes in quality and intensity must fuse in such cases into single complex recognitions of direction.

Distance of sounds recognized only indirectly.

The foregoing discussion of binaural localization in direction may be supplemented by reference to the fact that the recognition of the distance of sounds involves a large body of organized experiences. If one hears the human voice sounding very faintly in his ears, his frequent experience with voices and their normal intensity when the speakers are near at hand will lead him to recognize that the person speaking is far away. Furthermore, the qualitative character of the sound as well as its intensity is modified by the remoteness of its source, the elements of the sound being less distinct when it is transmitted from a great distance to the ear. The intensity and quality are, accordingly, both utilized in interpretations of distance so long as the sound is familiar.

Unfamiliar sounds difficult to locate.

In contrast to the relatively easy estimation of the distance of a familiar sound, it is extremely difficult to estimate the distance of the source of an unfamiliar sound. An experiment may be tried by producing an unfamiliar sound, such as that which results from snapping a card in the neighborhood of an observer's head. Until this sound has become familiar the errors in estimation of distance will be very noticeable.

Summary of conclusions regarding auditory space.

The complexity of auditory space perception is more evident than the complexity of tactual space perception. So, also, is the dependence of auditory space upon other forms of spatial organization. We may conclude this survey of auditory space with a reiteration of the conclusions reached at the end of the earlier section on tactual space.

C. Visual Space

Optical illusions.

If we turn from auditory space perception to visual experiences, we find a rich variety of different forms of space perception. There are certain cases of incorrect perception of length and direction of figures in plane surfaces, constituting what are known as geometrical optical illusions. These are especially clear examples of complex perception. They are also instructive to the student of psychology because they show that perceptual interpretation is not a mere copy of external

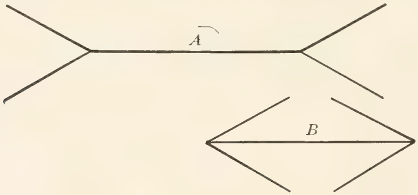

Fig. 42. Müller-Lyer illusion. The length of the horizontal line A is equal to the length of the horizontal line B. For further discussion of the figure see text.

reality. Take, for example, the illusion represented in Fig. 42. The two lines A and B are in reality equal to each other, but the observer will recognize at once that they seem to be of different lengths. The retinal image of each line is distinct and clear; the apparent inequality cannot, therefore, be attributed to any confusion in the retinal processes; it must be attributed to some kind of perceptual complexity. The explanation of the source of this illusion has been the subject of much discussion, and it is probably true that no single statement will account for the apparent inequality of A and B. In a general way it may be said that one cannot look at A and B without including in his field of vision the oblique lines, and the oblique lines are

such striking and unfamiliar additions to the long lines that they are not neglected as they should be in perceiving the length of the horizontals. If, in addition to this general statement, we attempt to show in detail how the oblique lines affect the horizontals, there are a number of facts which may be noted. The oblique lines produce less of an effect upon some observers than upon others. This can be shown by making quantitative determinations of the intensity of the illusion. For this purpose one of the figures of the pair under discussion is made adjustable, and the observer sets it until it seems to him equal to the other figure. When the two seem equal, they will be in reality different. The amount of difference can now be readily measured, and the results from various observers compared. Not only are the results of such measurements different for different observers, but the same individual will at various times give different results. One especially significant case of individual variation is that in which the observer deliberately sets about comparing the figures a great number of times for the purpose of becoming familiar with them. Three stages of change in interpretation show themselves in such a practice series. First, the observer takes a general view of the whole figure, as does the ordinary observer who looks casually at the illusion; he gets in this case a strong illusion. Second, the observer tries to look at the long lines and neglect the obliques; that is, he makes an effort to overcome the disturbing influence in a negative way. During this period of conscious neglect of the obliques, the illusion grows somewhat weaker, but it does not disappear. Finally, in the third stage, the observer reaches the point where there is no need of an effort to neglect the obliques. Interpretation may be said to be so completely worked out in this stage that the obliques and the long lines fall into their proper relations without interfering with one another. Each is included in the percept, but in its true significance. At this stage the illusion is entirely overcome.

Quantitative determinations of the amount of the illusion.

Effects of practice.

Such facts as these make it clear that a visual percept

The recognition of every line in the visual field is influenced by the surroundings of the line.

includes all the factors in the field of vision. If these factors are conflicting, they may result in grotesque misinterpretations. If, on the other hand, they are thoroughly assimilated into the percept, they take their appropriate relations and no longer disturb the total process of perception. A great many other illustrations could be brought forward to show the relation of one part of the visual field to all other parts. Thus, one cannot look at a line on a large blackboard and fail to be influenced in his estimation of the length of the line by the large surrounding space. Conversely, a line drawn on a small sheet of paper is always interpreted in terms of the paper as either relatively long or relatively short. Objects seem very different in size when seen outdoors, and again in a small room. Figure 43 illustrates this principle by showing a short central

FIG. 43. The middle portion of the short horizontal line marked off by the verticals seems longer than the equal distance marked off in the long horizontal line.

line as part of a long line in one case and as part of a short line in a second case, with the result that the central line seems to be of different lengths in the two cases.

Other facts also show that size is a matter of relations.

Other complications than those from the surrounding visual field also influence one's perception of size. The natural standards of size which depend upon familiarity and upon the relations of objects to one's own body are constantly influencing perception. Time and again descriptions have been given by observers of the fact that a road seems longer the first time one passes over it, when all the sights are unfamiliar; and many have also referred to the fact that places known in childhood always seem small when revisited in mature life.

The significance of all these facts for our understand-

ing of visual space is not hard to find. Putting the matter in physiological terms, we may say that when series of visual stimulations from a given line or figure reach the visual center, they find there a larger series of excitations from other points on the retina. There is also a more or less completely developed series of tracts leading out of the sensory area toward the association areas and motor areas. If the stimulation is discharged through a path which results in the movement of the eyes along a single line, or if the special form of activity consists in holding the eyes fixated on a single point, the activity can be properly executed only when all the retinal stimulations are coördinated so as to flow harmoniously into a single motor tract. The coördination of the various sensations may not be complete in some cases; that is, the various sensory factors interfere with each other, obliques, for example, conflicting with horizontals; there will then be evidences of conflict in the percept and in the movement. Every eye movement and every fixation is thus a product of organization, in which the various sensory factors in the field of vision are given recognition either in a well-coördinated manner or in some type of illusion. It is not true, as is often supposed, that we neglect the visual impressions which lie outside of the point of fixation. We use these outlying sensations as the framework for the lines and figures which are at the center of recognition. Sometimes, as in a strong illusion, the outlying sensations are not yet assigned to their proper functions as framework for the central part of the figure, but are incorporated into the figure itself. Then the perceptual process will be complicated by these additional lines, and an illusion will result. The complication occurs even when no actual movement is executed, because the total organization of the associated central tendencies is in the direction of the distracting factors.

Physiological conditions of visual perception.

A clearer understanding of the matter will be reached by considering the results of photographic investigations, in which the path of the eye movement in looking over certain illusory figures has been determined.

Photographic records of eye movements confirm the view that perception and movement are closely related.

In Fig. 44 there is presented one of the most striking of the illusions of direction. The long lines are in reality parallel with each other, but the obliques are far

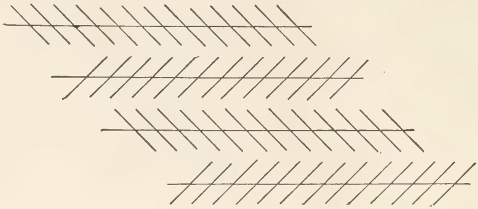

Fig. 44. Zöllner illusion. The long lines are parallel with each other.

too distracting to permit the ordinary observer to recognize the true relations between the parallel lines. Figure 45 shows another illusion of direction. The oblique lines are parts of a single line, but seem to extend in slightly different directions because of the interrupting space between the parallels.

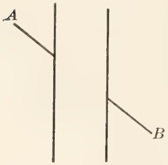

Fig. 45. Poggendorff illusion. *A*, *B* are parts of the same straight line.

Figure 46 shows the paths in which photographs indicate that the eye of an observer moved in attempting to look at the illusions discussed. In *A* the movement over the Zöllner pattern is shown. It is evident from the movements indicated in the photographs that the sensation factors are not fully mastered so as to permit coördinated movements along the parallel lines. The result is that, though these lines give perfectly clear retinal images, they do not stand in their true relations in experience. The photographs show that often there is sufficient fusion of the sensory factors to permit a single movement in following a line, and this single movement is in the general part of the field of vision

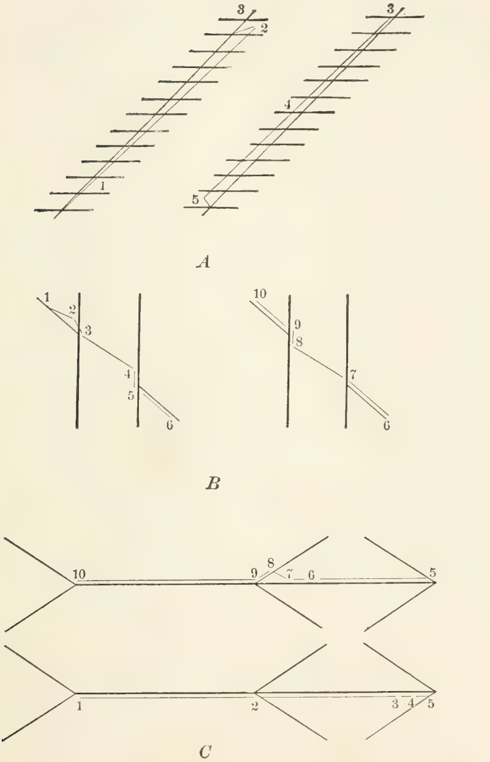

FIG. 46. These figures show the path followed by the eye of an observer in examining certain of the foregoing illusions. In each of the figures the path of the eye movement is indicated by a supplementary line. The numbers placed along these supplementary lines indicate the points at which a pause was made [See following inscription at bottom of next page.]

in which the line lies, but it is only a gross general approximation to the line. This corresponds exactly to the fact that the experience of the figure consists of a gross general perception of the long line and its obliques. One observer, after these preliminary photographs of his eye movements in looking at the Zöllner pattern, put himself through a series of quantitative tests with the figure. In this practice series he gradually overcame the distracting effects of the oblique lines, and the illusion disappeared. A second series of photographs taken after the practice series showed that his eye followed the long line with great precision. Photographs with other illusions show clearly the distracting effects of the additional lines as indicated in full in Fig. 46.

Relation between size and distance. When we study in plain figures the relation of size to distance from the observer, we find a series of complexities even greater than those which have appeared thus far. In order to demonstrate this experimentally, an observer should first secure an after-image through the steady fixation of some bright object. The after-image covers a certain number of retinal elements, and may be considered as giving, as long as it lasts, a constant group of sensations. When the observer is looking at the object, this mass of sensations will be interpreted as having a certain definite size and distance. When the same mass of impressions comes from the after-image, it

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in the course of the eye movement. In Fig. *A* the observer was attempting to follow the long line of the illusion. It will be noticed that he departs from the long line, and at the extreme end of the movement, as at *2* and *5*, makes a short corrective movement by which he again fixates the long line. In Fig. 46 *B* the distracting influence of the vertical lines is obvious, as is also the difficulty of moving the eye across the open space in any such way as to reach the point of interconnection between the vertical and oblique lines. In Fig. *C* it will be noted that the eye movement is very free in that part of the figure which is overestimated, and much restricted whenever the eye approaches one of the acute angles. This is indicated by the frequent pause in *3*, *4*, *6*, *7*, *8*, *9*. In *8* it will be noted that the eye is deflected from the horizontal line by the oblique.

can easily be related to different distances, and with each change in apparent distance it will take on a different apparent size. The change in distance can easily be produced by looking at various surfaces which are at different distances. The after-image will seem in each case to be on the surface at which the observer is looking at the moment, whatever the distance of that surface. The after-image will seem smaller when the surface on which it is projected is nearer than the original object from which the image was derived, and larger when the surface is farther away.

There is a definite optical relation between the distance and size of an object and the size of the retinal image from this object.

This series of observations makes it clear that the size of a retinal image does not determine the interpretation of the size of an object without reference to the additional fact of distance. A given retinal image, for the after-image on the retina remained the same throughout the series of observations, may be interpreted as a large object far away or as a small object near at hand. The optical principle which underlies this series of observations is illustrated in Fig. 47. In this figure the

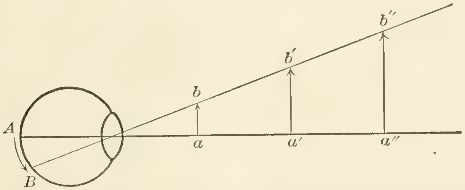

Fig. 47. The retinal image AB may be equally well related to any one of the objects ab, a' b', or a'' b''.

retinal image is represented by the inverted arrow AB, and the lines from the extremities of this image passing through the optical center of the lens determine the positions of various external objects, any one of which satisfies the image. It will be seen from this drawing that a succession of arrows outside of the eye, differing in length from each other, may all cast the

same retinal image. This general principle is doubtless familiar to every one when stated in the following simple terms: A small object such as the finger held near the eye can shut out the image of a large remote object, such as a tree or a building. When, now, the after-image in the experiment is projected to distances near and far away, its significance and perceptual interpretation are immediately modified, even though the retinal sensations are uniform in volume and distribution on the sensory surface of the eye.

Interpretations of size and distance cannot be made without reference to each other.

The complement of the foregoing experiment with the after-image can be tried in the laboratory by placing the observer in a dark room where only a single object is visible. Let this single object consist of an area of ground glass uniformly lighted from behind and controlled with reference to its size by a diaphragm which can be opened and closed in such a way as to keep all of its dimensions in a constant relation to each other. If the observer looks at such an area with one eye, and the area is moved backward and forward or held at a given distance and changed in size, it will be found that it is quite impossible for the observer to determine whether the changes in his experience are due to changes in the size of the retinal image which result from a movement of the object to a greater or less distance, or to changes which result from the closing or opening of the diaphragm. This shows, as did the experiment with the after-image, that the size of a retinal image is not an adequate basis in experience for the interpretation of the size of the object. The retinal image has always relative value only. The factor of distance enters into interpretation, as indicated in the experiments above described, and the distance must be interpreted in every case, or the size of the object is not determined.

Berkeley's statement of the problem of visual depth perception.

These observations lead us to a problem which was so clearly stated by one of the early writers in the modern period of psychology that we may quote his statement in full. In a treatise published in 1709, Bishop Berkeley said: "It is, I think, agreed by all that distance of itself, and immediately, cannot be

seen. For distance being a line directed endwise to the eye, it projects only one point on the fund of the eye — which point remains invariably the same, whether the distance be longer or shorter. I find it also acknowledged that the estimate we make of the distance of objects considerably remote is rather an act of judgment grounded on experience than of sense." Berkeley goes forward in the remainder of the *Essay toward a New Theory of Vision* to account for this process, which he calls a process of judgment. He draws attention to the fact that whenever one looks at an object near at hand he turns his eyes inward in such a way that the points of view from which he observes the object are different in the two eyes, and the two axes of vision converge upon the center of attention. The convergence of the two eyes, he asserts, gives rise to certain experiences of movement, which are utilized as interpreting factors.

Experiments show the dependence of the perception of depth on the two eyes.

Whatever may be the agreement or disagreement of modern psychological views with this conclusion of Berkeley's, it is clear from the outset that a problem has been stated in terms which are familiar to the student who has learned to recognize in spatial arrangements complex forms of mental activity. Fortunately for psychology, the problem of the recognition of visual depth is one of the easiest problems in space perception to subject to scientific analysis. If it is true, as Berkeley stated, that the two eyes coöperate in furnishing the data necessary for depth perception, then it should be possible to show that the recognition of depth is seriously interfered with by the withdrawal of any of the factors contributed by the two eyes. Later investigations have made it certain that Berkeley was right in this matter. It is possible to show by very simple experiments that the two eyes contribute very largely to the recognition of depth. It is not possible to remove altogether the influence of both eyes, even when one is closed; hence, vision can never be reduced to strictly monocular vision, but the following simple experiment may be tried to show the dependence of the clear recognition of depth upon vision

Experiments with monocular vision.

with two eyes. If an observer covers one eye and then attempts to bring his finger directly over some object which stands in front of the open eye, he will find that the ability to bring the finger directly over the object in question is very much less than his ability to do so under the ordinary conditions of binocular vision. A direct observation of the same general fact can be made, if the observer will note carefully the difference in the apparent solidity and remoteness of objects when he observes them first with a single eye and immediately afterward with both eyes open. These observations show that the complete recognition of depth involves all the sensory factors from the two eyes; whenever there is any disturbance of the normal conditions, the result appears in incomplete perception, for the relational or perceptual process does not in such cases have its normal complex of content with which to deal.

Difference between the images in the two eyes.

The contributions made to experience by the two eyes are different, as can be clearly seen if an observer will hold some solid object near the face, and look at it, first with one eye open and then with the other. The difference between the two views in the two eyes can be briefly defined by saying that with the right eye one sees more of the right side of a solid object and less of the left side, while with the left eye one sees more of the left side of a solid object and less of the right side. These relations are made clear in Fig. 48. When the two retinal images from the solid object are received by an observer, they are immediately fused with each other into a single perceptual complex, as were the two groups of auditory sensations discussed in an earlier section of this chapter.

Ordinary lack of recognition of binocular differences is due to fusion.

Enough has been said in the discussions of auditory localization to make it clear that the process of fusion of two groups of sensations is not, either in the case of hearing or vision, a separate conscious activity in which the two groups of sensation factors are first considered apart and afterward bound together by some additional mental effort. Experience has, in both cases, gradually developed in such a way that the total

mass of sensations received through the two ears or the two eyes, fuses in each case into a single experience which reflects in its spatial arrangement its complex origin, but does not betray its complexity in any directly observable separation of the factors of sensation. The result is that it is quite impossible, by any form of introspection, to determine while looking at an object with both eyes, which factors of experience arise from the stimulation of one retina and which factors arise from the stimulation of the other retina. It is only when one eye is closed that we are able to distinguish between the factors which enter into composite binocular vision. When observations are thus made with a single eye, after closing the other eye, it is shown conclusively that there is a difference between the two retinal images derived from a solid object.

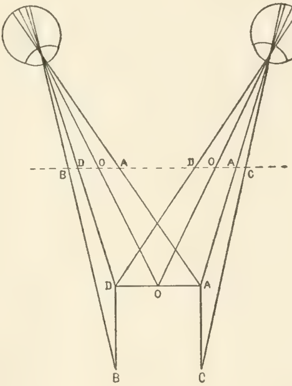

Fig. 48. Showing binocular parallax. The cube *BDAC* is held near the two eyes with the result that the right eye sees the surface *DA* and the right side of the cube, while the left eye sees the surface *DA* and the left side of the cube. If a plane is passed through the rays of light which enter the eye from the cube, as indicated by the dotted line in the figure, it will be seen that the retinal images of the two eyes contain each a distinct element. The eye on the left-hand side of the figure has a retinal image corresponding to *BD*, which is absent in the other eye. Further details will be obvious from the figure.

There is an apparatus often used for purposes of amusement, in which the principle that the appearance

Stereoscopic figures give appearance of solidity by reproducing natural conditions of depth perception.

of solidity depends upon disparity of the two retinal images, is utilized to produce the appearance of solidity even when no solid object is present. The apparatus in question is the stereoscope. Photographs are taken or drawings are made, corresponding in form to the retinal images which would be obtained by two eyes if they were looking at a solid figure or series of figures at different depths. The two drawings or photographs are then projected by means of the stereoscope into the two eyes of an observer in such a way that the right retina is stimulated by the image appropriate to the right eye, and the left retina is stimulated by the figure appropriate to the left eye. The observer, who thus receives the sensory impressions appropriate to solidity, will naturally fuse the two images and will see in space before him a solid object which, in reality, is not there, but which is adequately represented by the two flat drawings projected into his eyes. A great many experiments can be tried with the stereoscope which make clear the significance of the two retinal images for the recognition of solidity and depth. It can thus be shown that the fused resultant, that is, the percept of a solid object, does not derive its characteristics from either one of the retinal impressions considered in itself, for each image so considered is deficient in solidity. The fusion is, in a very proper sense of the word, a compromise between the two different images, and there appears as a result of fusion at least one characteristic which neither figure had in itself; namely, the characteristic of clearly defined solidity.

Cases in which solidity does not appear.

The statement may be made that the percept of solidity arises as a compromise between two groups of sensory impressions which are sufficiently alike to lead to fusion, but are at the same time sufficiently different from each other to prevent their being interpreted as identical. In contrast to the usual disparity of images arising from solid objects, there are certain natural cases in which the two images from an object are so nearly alike that there is no perceptual compromise to give rise to solidity; and there are certain artificial cases which can be produced by the aid of the stereo-

scope in which the images are more radically different than are those derived from a solid object.

Flatness of binocularly seen objects due to like images.

When the images in the two eyes are alike, the object will be perceived as flat. If, in such a case, we consider not merely the single object but the whole field of vision, the conditions for the whole field will be found to be similar to those which appear in looking at a solid object. The whole field of vision as seen with the right eye differs from the field as seen by the left. The flat object which casts like images in the two eyes is consequently seen, because there is disparity in the images from the total field of vision, as placed at some point in depth, even if it does not have solidity in itself.

Retinal rivalry.

When the binocular images are totally different, as in certain experiments which may be arranged with the stereoscope, the observer finds that it is impossible for him to fuse the two groups of impressions. Thus, if he looks with one eye at a series of horizontal lines, and with the other at a series of vertical lines, he will see the fields in succession. The group of sensations coming from one retina will first be recognized in clear consciousness, and will then fade out and give place to the sensations derived from the second retina. There is thus an oscillation in experience which is vividly described by the terms retinal rivalry. In retinal rivalry there is obviously a lack of fusion of the sensations. The artificial differences in binocular images here produced are so foreign to the experiences which present themselves in ordinary life, that the observer is unable to fuse them into a single conscious process. If such strange combinations of sensations are to be in any way related, it must be in a temporal succession of mental activities, rather than in a single spatial form.

There are factors other than those contributed by the two eyes.

The recognition of depth through the fusion of two groups of retinal sensations is not the only form of visual recognition of depth. Other factors of experience, and other types of relation, may enter into the complex. In every case, however, the factors or relations which contribute to the interpretation of solidity are, like the differences in binocular vision just discussed,

complexes which get their significance and value, not because of their sensation qualities, but by virtue of the relations into which the sensations are brought.

Aërial perspective.

The first facts to which reference may be made are the differences in colors and sharpness of outline which appear when objects are seen through different thicknesses of atmosphere. Remote colors are always dull and darker in shade than colors near at hand, and the outlines of remote objects are ill-defined. We are so trained in the interpretation of these general facts that we pay very little attention in looking at a landscape to color quality or to the lack of clearness in outline, but utilize these immediately for purposes of depth perception; that is, the sensations are not recognized as distinct facts in experience, but are allowed to serve their function, which is to indicate the position of the object from which they come. Let the observer carefully compare his experience of distant fields in the landscape with fields near at hand. He will find that the remoter greens are blue in cast, even though under ordinary circumstances his attention is not directed to these differences in color shades. The same truth is well illustrated by the fact that persons who have been accustomed to living in a moist atmosphere always misinterpret distances when they go to regions where the air is clear and free from moisture. Great distances seen through clear air are underestimated because of the small effect which the air produces in modifing the colors and outlines of objects.

Geometrical perspective and familiarity.

Another important means of recognizing depth is through the familiarity which we have acquired with certain common objects. If a given object is carried farther and farther away from the eye, it will cast upon the retina a smaller and smaller image. If a man, first observed at a distance of ten feet, moves to a distance of twenty feet, the size of the retinal image and, consequently, the mass of sensations derived from this man, will decrease one half. We seldom interpret such changes in the size of a retinal image of a familiar object as changes in the size of the object itself; thus, we never say that a receding man has dwarfed to half

his original size. We have learned by long experience that most of the objects of our environment are permanent in size, and that the changes in our sensations merely indicate changes in the position of these objects. In this way we build up an elaborate series of recognitions of differences in depth. How completely we depend upon this recognition of familiar objects for our interpretation of unfamiliar or undefined experiences will be recognized, if it is remembered that the interpretations of the size and distance of objects in photographs is always uncertain unless some familiar figure, such as that of a human being, appears as a scale by which to gauge the sizes of the other objects.

Shadows.

Another factor which is sometimes significant in giving rise to the interpretation of depth is found in the shadows cast by objects. The apparent solidity of a bank of clouds in the sky cannot depend upon binocular differences, because the clouds are too remote. They are also quite unfamiliar, and may be without color; therefore, the methods of interpretation which we have described up to this point are quite inadequate to explain their apparent solidity. The shadows which they cast upon each other are, however, so clear in their indication of differences of position with reference to the sun, that we immediately recognize a bank of shaded clouds as made up of parts differing in distance from us. The same principle of recognition of solidity is utilized in all flat drawings intended to represent solid objects. Such flat drawings can always be made to suggest solidity with vividness when they are shaded in a way corresponding to the objects themselves.

Intervening objects.

Finally, we make use of the fact that near objects very frequently cut off our vision of remote objects. Thus, if a tree which can be seen in all of its parts cuts off a portion of a house or other object, we perceive the house, not as divided by the tree, but as standing behind it. Here again we interpret our sensations as indicating differences in position rather than differences in the objects themselves.

One cannot review this series of facts with regard

Depth is a matter of complex perception.

to the visual interpretation of depth without being confirmed in his view that space perception is a process in which sensory factors are related to each other in the most complex manner. No retinal impression has its value for mental life fully determined until it is brought into relation with other sensations.

Theories of visual fusion.

The full explanation of the details of the processes of interpretation here involved has been the source of many disputes in the history of psychology. As we have already indicated, Berkeley regarded the process of fusion as one of judgment; whereas, we shall find when we come to study judgment, which is a complex in which the factors are explicitly recognized as separate, ample reason to distinguish judgments from immediate perceptual fusions. Many writers later than Berkeley have regarded sensations of movement derived from the muscles of the eyes as of prime importance in combining retinal sensations. Still others have assumed that the retinas have certain congenital correspondences which provide for the bringing together of excitations received at certain points in the two eyes.

The most complete explanation is that which includes all factors in a system of central coordinations.

The formula which will extricate us from these conflicting theories is the formula of central coördination which was suggested in the introductory discussion of sensation functions. All the earlier types of explanation which have been advanced have one characteristic in common; they recognize fusion, especially binocular fusion, as a complex process in which a number of sensory factors are united. Our present discussion may, therefore, assume complexity without further argument; the problem which remains is to show the nature of this complexity. We may explain this crucial case of binocular fusion as follows: First, fusion is not due to any simple flowing together of sensory processes. Second, the fusion of binocular images is closely related to certain processes of ocular movement, which can be shown to be in their development matters of gradual organization, and in their present form, complex coördinations. Third, the processes of motor adjustment of

all parts of the body furnish urgent motives for fusion and serve in part to explain why retinal impressions from the two eyes are united into single unitary percepts. Fourth, the conclusion to be drawn from these discussions is that the unitary experience derived from binocular vision is related to nervous organizations in the central nervous system, where the manifold of retinal sensations is reduced to the unity necessary for coördinated reaction.

Experiments show that sensory processes do not flow together.

With reference to the first step of the explanation; namely, the demonstration that binocular fusion is not a sensory process, an account may be given of a recent experimental investigation which puts the matter in a very clear light. Let us suppose for a moment that the stimulations received by the two retinas flow together as sensory excitations at some point in the central nervous system; then, so long as either retina is stimulated, there ought to be an experience of light. Even if the stimulation is alternated so that it affects first one eye and then the other, the supposed central receiving center ought to be continuously excited. An experiment was so arranged that each eye was stimulated by a succession of lights separated by intervals of total darkness. The intervals of stimulation and darkness were so related in the two eyes, that while one eye was in darkness the other was stimulated. The sensory excitation from the point of view of the single eye was intermittent; from the point of view of the two eyes there was always positive excitation entering the nervous system. The outcome of these experiments as reported by their author is as follows: "The broad outcome of the observations is that so far from bright phases at one eye effacing dark phases at the corresponding spot of the other eye, there is hardly a trace of any such interference." The fact that binocular impressions fuse is, therefore, not to be explained by assuming that sensory excitations flow together. The fusion must be a process lying beyond the receiving centers in the brain.

A study of the ocular motor processes related to

Fusion and binocular movements are most intimately related.

binocular vision gives more significant results. In the first place, it may be noted that infants do not have fully developed coördination of the two eyes. When an infant attempts to turn the two eyes on the same point of fixation, his movements are frequently so slow and irregular that they have the appearance, especially in photographs, of cross-eyed movements. Even in adult life, it is shown by rapid photographs that the two eyes often move to a point of fixation in such a way that while one eye moves rapidly, the other comes up in an irregular, relatively slow movement. The development of a coördinated movement is thus seen to be the product of effort and concentration. That a coördinated movement has been developed at all, shows how significant it is for the individual that he should acquire a unitary motor response to the complex of retinal sensations. The unity of response stands, indeed, in sharpest contrast to the complexity of the sensory factors. The organized ability to coördinate the two eyes depends on the development of a system in which each phase of experience without losing its individual reality, is taken up in the single unitary system. Space and the coördinated system of ocular movements are thus seen to be very intimately related. The complex of movements has a unity which results from the union of all of the different phases of binocular movement into a single coördinated act. Space is also a system in which every point has a certain character of its own, and at the same time has characteristics which attach to it as part of the general system.

General bodily movements demand fusion of retinal sensations.

The relation of visual space perception to organized behavior becomes clearer when it is noticed that the unity of visual percepts is demanded, not only in the coördinations of eye movements, but also in the coordinations of all forms of behavior which are guided by vision. If one reaches out his hand to grasp an object, his sensory impressions of the object will be derived from two eyes, but the reaction to be effective must be to all the sensations at once, and must be so directed as to give a coherent series of responses for

different parts of the object. Unity on the one hand, and separation into parts on the other hand, are so admirably provided for in this formula of reaction, that movement has always been recognized as intimately related to the perception of space. Many writers have been impressed with the importance of movement for space perception, but have been so devoted to the formula that all mental processes must be reduced to sensory factors, that they have held that movements aid in space perception only through the sensory factors which they contributed in the form of sensations of movement. Our discussion has led to the point where we can recognize the significance of movement from an entirely different side. It is not the movement after it has been executed and reported back to consciousness that is of importance; it is rather the organization of experience and of nervous processes into a coördinated system with motor adjustment as its end, that gives to the sensation factors a function and relation superior to their individual quality. Space is not the sensation of movement, but rather the system of relations between all sensory factors involved in guiding a reaction.

The physiological processes of organization important in explaining space are in the association regions.

Such considerations as the foregoing, in which binocular space is related, not to the incoming sensations, but rather to the organized system of responses, lead us directly to the conclusion that it is central association processes which condition binocular fusion. These central associations have been built up under the demands of practical life, and have not grown out of mere sensory qualities, even qualities of muscle sensations. This statement can be reënforced by repeating the discussions of earlier paragraphs. It was there pointed out that the spatial form of tactual and auditory percepts is the same as the spatial form of visual percepts. This can never be understood if the causes of perceptual fusion are sought in sensory qualities. Sensory impressions are received through a great variety of organs which, because of the demand for specialization and adaptation to the stimuli coming from the external world, have been distributed over different parts of

the surface of the body. Through the processes of sensory differentiation, the impressions from different parts of a single object are often received, not only by different sensory cells, but often in the form of qualitatively different sensations. Experience must somehow restore the unity which exists in things, and at the same time reflect the manifoldness which has been provided for in the development of sensory differentiations. The central nervous organs constitute, as we have seen in earlier discussions, the system in which all the bodily functions are unified and organized. It is here that we must look for the processes which parallel what we have called fusion. Indeed, the fact that consciousness presents a unified resultant of all the different impressions which enter into our single spatial form, is additional evidence that there must be in the central nervous system some coördination and organization of the disparate impressions.

Every sensation must enter into functional relations.

The study of perception and the effort to arrive at a description of the physiological processes underlying perception is the best possible corrective for any disposition to regard sensations as separate and independent factors existing in the mind as mere qualitative elements. Everywhere we find that there is more than mere sensory process; there is combination and fusion, and this combination is not determined by the sensory factors themselves, but rather by the larger system of experience into which the sensations enter as factors.

Space is not a mental construct.

The statements made regarding the central nervous coördinations may be criticised as somewhat vague. They are, indeed, less definite than the description of the conscious facts with which they are related. We are in direct introspective contact with the conscious products of perceptual fusion, but we know very little in detail of the central nervous processes of coördination and fusion. Our psychology could describe the facts of experience in this sphere very fully without referring to the nervous processes. We should then lose, however, the advantage which was gained by relating consciousness in an objective way to nervous

organization, and we should the more easily fall into the erroneous conclusion which has appeared from time to time in the history of thought; namely, the conclusion that space is a mere mental figment. Space perception is a phase of experience which, undoubtedly, has physiological conditions of a highly developed type. Space perception is no less conditioned by bodily organization than is sensation. The character of space experience is different from the character of sensation, but both are processes related to objective reality and both have the same fundamental character, in that they are results of contact between an organized individual and his environment.

Space is not the only product of fusion.

Up to this point our discussions of space have dealt with a variety of special cases and with the general fact that space perception is a form of organization; no attempt has been made to show how space differs from the other phases of perceptual organization. The necessity of distinguishing space from other phases of perception is, however, clear the moment one considers that the position or size of a perceived object is not by any means all that is recognized when the sensations from this object are united into a percept. Thus, one may hear a sound and locate it on the right side and then go much farther in recognizing it as a human voice or the report of a gun. These latter phases of interpretation require special consideration, and, even though the general formula of the functional relation of sensations will doubtless help us in understanding them, they must be explained in detail as distinct from space.

Space after it is developed becomes a relatively independent phase of experience.

The spatial attributes of all percepts unite more than any other group of attributes into a single closed system, so that we come to speak of space as if it were a single, well-defined somewhat in consciousness, capable of existing apart from the particular percepts in which it is exhibited. Thus, as was pointed out above, we have tactual space percepts and visual space percepts and space percepts in other spheres of sensation, and we find all these different percepts arranged in one single general space form, to which we refer as including

the tactual, auditory, or visual contents. This compactness and uniformity of the spatial system must have its counterpart in human structure. And investigation shows that it has. Human central organization and consequent movements are, from the very nature of mechanical law with which the movements must comply, capable of only a very definite system of developments. One cannot move his hand at the same time toward the left and the right. Left and right come to be, therefore, clearly distinguished directions in the organization of human responses to sensations. One cannot move his hand backward and forward in the same movement. As a result, all sensations which are to be related to movements are ultimately assigned to places either in front or behind, never in both positions at the same time. The child begins life without a thorough organization of his movements, and, correspondingly, without any definite spatial forms of perception. The two develop together as he actively adjusts himself to the world about him. Finally, as he becomes master of his movements, he finds that his perceptual world also has taken on certain definite sequences of arrangement which are so stable and systematic and so harmonious with what he comes to know theoretically of mechanical law, that he can study the spatial system as he finds it in his perceptual consciousness and relate this spatial form of perception to his science of mechanics, without the slightest fear of finding any incongruity in the two groups of facts. It should be noted here again that such a complete system of space is much more than a series of sensations. Sensation qualities are necessary as the factors with which the individual must deal; they constitute the material or content of experience, but the spatial form of perception is a functional relation. Every sensation is related to every other, not because of its quality or intensity, but because, in the organization of impressions, every sensation must take its place in a serial system before it can serve any definite function in individual life or have any clearly marked place in consciousness.

Space is one of the most fundamental forms of organization.

Once the mechanical necessities of movement have been complied with, there may be the greatest possible variety in the details of behavior. Thus it comes that the spatial arrangement is by no means the only type of organization exhibited in perceptual processes. But whatever the variety in the details of special acts, the ever present compliance with the fundamental necessities of spatial arrangement is the first requirement. Hence, space is a form of all perception, whatever other modes of relation appear.

Certain sensations serve their chief or only function in directing movements in space.

One further line of consideration will serve to reenforce what has been said regarding the fundamental inclusiveness of the space form. There are various groups of sensations; notably, those which come from the muscles, joints, and from the semicircular canals, which under ordinary circumstances receive very little explicit attention to their peculiar qualitative attributes. Indeed, we often speak of these sensations as wholly unrecognized. The reason for this lack of attention to such sensations is clear in terms of our discussion of space perception. These sensations have been completely taken up into a thoroughly organized system of responses. They serve their function exclusively in initiating and checking bodily movements. They are not occasions for new, elaborate forms of behavior. They come to constitute, therefore, the settled background of all percepts. The presence of certain sensory impulses from the semicircular canals constitutes in every perceptual combination the sensory basis for that fundamental and familiar arrangement which makes us recognize the perceptual world, whatever its details, as right-side up, stable, and orderly. This accounts also for the far-reaching changes which come in the apparent stability of the whole perceptual world when, through dizziness or even through an inverting of the head, the semicircular canals contribute unwonted sensations.

II. UNITY OF OBJECTS

Unity of perceived objects is a product of analysis and synthesis.

There are many forms of perceptual fusion which supplement the fusions entering into the closed system of space. Thus, when one looks at the book before him he not only localizes it, he also recognizes it as a distinct object. The experience of this object can be recognized as made up of a variety of sensory qualities. There is, on the other hand, a well-defined unity in the experience of the object, which consists in the fact that the sensory factors derived from it are related in a more intimate way than are the factors derived from the surrounding objects. This intimate relation between sensations from any clearly perceived object is a development within the individual. One can easily find illustrations of incomplete recognition of objects when all the sensory factors are present, but the perceptual unity is absent. From this stage of incomplete perception, there may be observed all grades of development up to the most compact forms of clear recognition of individual objects. When, for example, a powerful sensory shock is received from a clap of thunder or the unexpected slamming of a door, there is, for an instant, an approach in experience to pure unfused sensation. The characteristic fact in such a case is that there is no object in mind. The whole experience is filled with a vague mass of sensation, but there is no delimitation, no discrimination of one object as distinguished from the mass. Another illustration appears when one first enters a new place, as, for example, a brilliantly lighted room. The mass of experience is the most impressive fact. No single object stands out as yet; experience is a confusion. Gradually, the total mass of impression begins to subdivide. Certain impressions separate from the total mass and enter into compact relations. The unity of a given object is always due, as shown by such illustrations, to a double process of analysis and synthesis. The analysis consists in distinguishing one part of the mass of sensation from the rest. The

synthesis consists in holding the appropriate factors together. In practical life analysis is likely to be more obvious than the synthesis. Thus, when one observes a human figure in the distant landscape, the recognition of the patch of color sensation as a man involves much combining of the visual sensations with each other, but the more easily observed fact is that the man has been distinguished from his environment. The synthetic process involved in every percept of a thing is capable, however, of as clear demonstration as is the fusion involved in space perception. A single illustration will make this clear.

Fusion of tastes and odors.

To the ordinary observer, an object recognized through the two senses of taste and smell is so unitary in character that he does not realize that any fusion of discrete sensations has taken place. By a simple experiment one can easily show that the perception of any article of food involves a number of distinct sensations. Let the observer taste of some familiar substance, such as coffee, and at the same time prevent the air from coming into contact with the olfactory organ, and coffee becomes a sweet liquid with little or no flavor; even castor oil becomes an inoffensive thick oil under like conditions. Why is it that in ordinary experience tastes and odors are united? It is because, in spite of the separation of the gustatory and olfactory organs, there is a constant demand in life that tastes and odors shall be used together in guiding conduct. The whole inner organization of the individual is such that these different sensory qualities have a joint significance for perception and for behavior. There is a distinction on the qualitative side between tastes on the one hand, and odors on the other, because the sensory organs for the two qualities are different; but there is the most intimate perceptual fusion of an immediate form analogous to the spatial fusion, with which we became acquainted in the earlier discussions.

There are perceptual fusions in every sphere of sensation quite as compact as those of taste and smell

Percepts of things involve great variety of fusions.

and as various in character as the objects in the world about us.

Mere coexistence of sensations will not explain the unity in the percepts of objects.

The physiological condition of this unity in the perception of single objects is not to be found in the sensory processes themselves, any more than was the physiological condition for the perception of space. The sensory processes derived from things are very different in type and in the points at which they are received into the central nervous system. The unity of perception is not to be accounted for by the fact that all the sensory excitations are in the brain together, for, as has been pointed out, there is a very large element of analysis as well as synthesis in perception. The recognition of a table as unitary, at the same time that it is distinguished from its background, which is also sending stimulations to the central nervous system, shows that the unity of the table is perceived through some kind of a process which involves analysis. The mere coexistence of sensations is, therefore, obviously not enough to account for perceptual fusion.

The range of fusion determined by practical considerations.

Again, as in the treatment of the fusion which leads to space perception, we must appeal to the central coördinations which are worked out under the stress of practical demands. One fuses sensory factors into the percept of a thing, because he can adjust himself to the whole mass of experience in a single act. Thus, one speaks of a bookcase and its contents as a single object when he merely wishes to name over the articles of furniture in his room. He distinguishes the separate books as objects when he wishes to take them out and use them. The range of one's experience of a thing is thus seen to depend, not on sensory processes, but on the practical motives which lead to the synthesis of more or less comprehensive groups of these sensations into single phases of experience.

The development of fusions shows the character of the process.

The fusion of factors into single groups becomes easier after repetition. Thus, the expert rifleman comes to recognize at once the movement of his game, the distance of the game from himself, and the wind which will influence his shot, factors which might have coexisted indefinitely without being fused. All this

he has acquired as the result of repeated efforts to shape his conduct in accordance with the demands of his total environment. Indeed, such a case of acquired fusion of widely divergent sensory factors may very frequently involve in its earliest stages conscious effort to adapt action to whole groups of sensations. The unity is made more and more compact as repeated efforts are undertaken to recognize the factors together, so that ultimately the perceptual unity, which began in a conscious relating of factors, becomes a synthetic unity of the ordinary type, in which all the sensory excitations flow toward the motor channel in a single stream, and the sensory factors are fused, just because they are all phases of a single organized process of sensory-motor response. Such a case of complex and slowly acquired fusion is typical, and reveals the general practical character of all such perceptual processes.

Perception and habit develop together.

Discussions of perceptual fusion might be carried over directly into the discussion of habits, so as to show that the development of organized perception and the development of organized activity always go hand in hand. The training of eye and hand in any technical art, of ear and vocal cords in singing or speaking, of ear and hand in playing a musical instrument, go together in practical experience. The expert in every line not only acts more skillfully, but he sees or hears more skillfully and comprehensively. Perception is discriminative and complete just in so far as the factors of experience are organized into wholes appropriate for individual reaction. Our present purposes, however, can be fully satisfied without a complete study of habits. The perceptual fusion involved in the recognition of an object is one phase of organization; habit is an expression of this organization, and will be taken up in a separate, later chapter.

III. TIME

Time as a general form of experience.

Before leaving the subject of perception, it is important that we consider briefly a form of arrangement which has often been regarded as similar in character

to the space form; namely, time. Time, like space, involves a relation between several factors of experience. Like space, it is not a sensation quality. It is even more general in character than space, for it is not merely a form of perception; it is also, and indeed chiefly, a form of the indirect, or memory experiences. A percept is always in the time series, but it is always in that portion of the time series which we call the present. It will, accordingly, be appropriate for us to discuss in this connection some of the attributes of "the present," leaving the other phases of time consciousness to be taken up in connection with memory.

Experimental determination of the scope of "the present."

The present is not a single point of experience; it is a group of experiences. Some experimental evidence as to the possible length of "the present" may be gained, as follows: Tap rapidly on the table at intervals of half a second or less, producing a series of sounds, and find how many taps of this kind can be grouped into a single easily apprehended unity. The observer will have little difficulty in determining the limit of such a series, if he will simply listen to the taps and refrain from counting. A short series of five or six taps will leave behind in consciousness a feeling of perfect definiteness and ease of apprehension. If such a series is exactly repeated, or if a second slightly different series is sounded, the observer will be in no doubt as to the likeness or unlikeness of the two series. If, on the other hand, a series of twenty or thirty taps is sounded, the observer will recognize that at a certain point in the series a state of confusion sets in. The series is no longer apprehended as a unity, but has a vaguely defined massiveness which seems to elude the mental grasp.

The scope of the present varies with its content.

The ability of the observer to group together a series of experiences is radically modified when the series itself is changed. Thus, if every third tap is made stronger than the others, or if it is given a slightly different quality, the scope of the immediately recognized group will be much increased. If the taps come irregularly, either in point of interval or in point of intensity or quality, the scope of the unitary group will be decreased.

All these facts appear in such practical forms of time perception as those which are utilized in making up English verse. The recognition of the successive feet in poetry is facilitated by grouping the sounds into simple compact groups. The character of each group is determined by variations in intensity, quality, and content, in such a large number of ways as to satisfy the demand for novelty in experience, while at the same time retaining very fully the characteristics necessary for temporal uniformity in the successive groups of factors.

Time relations in verse and related systems of experience.

Time grouping is shown by these illustrations to be dependent, in a measure, on the character of the sensory impressions which are grouped. But the time order is something other than mere differences in sensation quality and intensity, for the mere existence of differences or of sequences will not explain the recognition of groups in experience. Time is a form of grouping which is not easy to explain, because it is so general. It must be related, so far as its conditions are concerned, to a much greater extent than is space, to very general conditions within the observer's central nervous system. If an observer's central nervous processes are under high tension, as when he is keenly expectant, the whole character of his time perception is different from that which appears when he is indifferent and relaxed. This puts time into sharp contrast with space, which changes very little with the observer's moods. Again, time is seen to be very general, because even in those cases in which external impressions offer no motive for time grouping; when they are, indeed, absolutely monotonous in their physical character, the observer will, for inner reasons, break up the monotony into intervals. This can be observed in listening to a uniform sound, for when such a sound is not broken by objective variations, it will be broken up into a succession of rising and falling accents by the listener himself.

Time has more general application, and must have more general conditions than space.

To find a precise physiological basis for the time grouping of experience will require the discovery of processes which are much more general than those

Time arrangement is connected with the rhythmical changes in nervous processes.

which constitute the physiological basis for space perception and for general perceptual unity as exhibited in the recognition of objects. Indeed, we must go far enough, as indicated above, to recognize that the conditions of temporal discrimination are involved in indirect memory processes, even more than in perception. Such a general characteristic is to be found in the fact that all nervous processes are constantly fluctuating in intensity. There is, for example, a rhythmical rise and fall due to inner causes which appears in all sensory excitations even when the external stimulus is quite uniform. This cannot fail to be reflected in some change in the sensations which are presented in conscious experience. They will be now weaker, now stronger, and considering the whole sequence, there will be an uninterrupted succession of changes. On the other hand, the practical activities of an observer can be carried on properly only when these changes are interpreted as not belonging to the objects perceived. There is, accordingly, a conflict in experience between the rising and falling intensities of sensations, and the demand for interpretations of permanency required for the guidance of behavior. This conflict leads to the development in experience of a form of interpretation which includes, at once, change and permanency. Permanency is exhibited in spatial organization and in recognitions of the unities of objects; the change is distinguished as a formal aspect of experience and is separated from the sensory qualities and from the space form and unity as a unique type of relation between the factors of experience. The fact of change in the midst of permanency is much more obvious when one considers, not merely the rhythmical rise and fall in sensation, but the marked changes in the vividness of experiences which appear in the course of memory.

Examples of the variations in sensations which furnish the basis of time perceptions.

One of the most obvious types of rhythmical change in perception is that which may be noted when one is receiving a very weak stimulus which is altogether uniform in physical intensity. Thus, if an observer picks out in the constellation Pleiades, a faint star

which is just visible, and watches it for a time, he will find that it disappears and then reappears for an interval, only to disappear again. The rhythmical change is here so complete that it is perceived as a change in the object. A like fluctuation of intensity is present in all sensory impressions, even if the sensation is so strong that its decrease in intensity does not cause it to disappear entirely. In most cases, however, as indicated above, the observer will be led to recognize through practical experience that objects do not undergo rhythmical changes. He will thus come to treat the changes in sensation, not as signifying that his interpretation of objects should change, but as signifying some kind of a series of modifications in experience, not attributable wholly to the things which he perceives, but belonging to the very essence of experience itself.

Motor processes are also rhythmical in character.

Change in intensity of sensations is not the only type of rhythmical modification in experience. Every series of activities which a reactor undertakes involves a constant series of renewals of effort. This is clearly shown in the physiological motor processes, where it is found that the nervous currents passing out of the nervous system to the muscles are sent out in successive waves, which waves, furthermore, are of varying intensity. One can observe by direct introspection that there is a rise and fall in the intensity of effort in almost all ordinary activities. Here again, it is easily recognized that the fluctuations in one's own efforts are not a sufficient basis for the reorganization of one's relations to things, even though there is an ever recurring necessity of renewing the effort.

The perception of movement.

Another significant series of changes in experience, which helps to build up the time form as distinguished from the space series or from the unity of objects, appears whenever there is a readjustment which maintains the unity of the object, but involves a movement from one point in space to another point. Thus, when a book is moved from one table to another, the perception of the unity of the object is not disturbed, but there is a complete readjustment of the spatial relations.

This involves a complex series of interpretative readjustments in experience. The perception of motion arises, and this may be described as both a percept and a complex of perceptions. Thus, it has been shown by various experimental investigations, notably by photographs of the eyes, that the visual perception of a moving object consists in a series of fixations and intermittent movements. The fixations are related to the unity of objects, the intermittent movements are related to the spatial readjustments. The total process involves a fusion of the complex of sensory factors into the three forms of arrangement: first, the unity of object; second, the spatial differentiation and arrangement of these objects; and third, the flux of one system of relations within the other. Such complexes as these show the comprehensiveness of perceptual organizations. That unity can be maintained in the midst of a moving group of sense objects shows that the interpretations in experience transcend by far the sensory contents which are used in building up these unities.

Perceptual forms no less real than sensory elements.

It may be well to make a remark at this time which was introduced in an earlier discussion and will be reiterated later. The various complex forms of mental interpretation, such as space, time, and unity of objects, are no more artificial and unreliable forms of experience than are sensory qualities. There has sometimes been a disposition on the part of thinkers to regard space and the other forms of experience as purely mental processes, remote from reality and incapable of being justified as fully as are sensory factors of experience. There is no ground whatsoever for denying to space as direct a relation to the external world as we attribute to red or green or blue. In fact, there is ground for the statement that space is a form of experience which is very much more fully and definitely organized and much more adequate to represent reality than any sensation which we have. The various types of experience should not be looked upon as measurable by their relation to sensations. Forms of interpretation are, it is true, different from sensation in character and condition,

but they have a character and validity of their own which sensations do not have. The curious historical tendency to regard sensations as more objective than space can be explained only by reference to the psychological error, which was referred to above, of attempting to explain all mental processes by their sensory elements without recognizing that experience is always made up of sensations in functional relation.

Summary of discussions of perception.

The discussion of perception may be closed with a brief summary. Perception involves, first, a spatial order; second, the compact fusion of sensations into percepts of separate objects in the world; and third, the beginning of a temporal order. The spatial arrangement is intimately connected with movement, being the arrangement given to sensory factors under the mechanical demands for characteristically different reactions to different sensory factors in the total mass of experience. Fusion of sensations into separate recognitions of objects is, like spatial arrangement, related to activity, for all those phases of sensory experience will be fused together which require, as experience develops, one and the same response. Finally, time recognition depends on the flux in experience which is primarily due to internal conditions, and comes to be recognized as a flux not interfering with the permanency of the spatial order or the unity of objects.

CHAPTER VII

EXPERIENCE AND EXPRESSION

Relation of consciousness to bodily activity not clearly defined in ordinary thought.

THE relation between experience and muscular activity is by no means so obvious to the ordinary observer as is the relation between experience and sensory processes. There are many movements which seem to take place without any definite relation to consciousness. Thus, one often winks his eyes without being conscious of the fact. There are internal movements in the organs of circulation and in the organs of digestion which are wholly unknown to us so long as they are normal in character. The effort to produce certain activities, furthermore, does not always seem to be effective, as when one strives to imitate a movement which he sees and finds that his bodily activity is altogether out of harmony with the desire which he has in consciousness. For such reasons as these, men have long considered muscular activity as related to consciousness only in a loose and irregular manner. The organs of sense have been recognized as the inlets for experience, but the muscles have not been recognized as the natural outlets for all sensory excitations.

Movements seldom presented as content of experience.

Even in scientific studies of the relation of bodily movement to consciousness, difficulties are likely to arise, because not all movements are presented in consciousness as explicit objects of thought and attention. A sensation quality, such as red or green, may be attended to as a definite content of experience, but a movement is very often related to experience in such a way that it is not an object or content of consciousness, as, for example, when a movement serves as a condition of an emotion of anger or pleasure, in the manner which will be discussed in later sections of this chapter. Only when movement is novel or unusually

intense is it thought of in the same way as are other factors of consciousness which are presented as sensations, and in these cases the movement becomes an explicit object of experience by first becoming the source of sensations of movement or the source of some other changes in sensory contents. It is for this reason that such discussions of activity as those which came up in the explanation of space perception in the last chapter are not so easy to formulate as are psychological principles which deal exclusively with sensations which can be thought of and described as definite contents of experience.

Movement and consciousness always related.

That there is a universal relation between consciousness and bodily activity can, however, be fully established. Indirect evidence of the universality and importance of this relation has been repeatedly discussed in earlier chapters. The structure of the nervous system from the hydra to man is such that there is always a motor organ linked with every sensory organ. This fact is enough, even if there were no striking introspective indications of the importance of movement, to concentrate the attention of the psychologist upon the motor side of nervous processes.

Activity does not always mean movement.

At this early point in the discussion of the relation of expression to experience, it is important to call explicit attention to the fact that motor activity does not always manifest itself in the form of movement. One may hold his arm rigidly in a fixed position and be doing more muscular work than if he were executing a movement through space. Or, to use another illustration, the erect position of the head is maintained by a constant contraction of the muscles of the neck. The tendency of the head is to fall forward if the neck muscles do not do their work, as is shown the moment one becomes drowsy and relaxes his activity. The head, after falling forward under such circumstances, is often drawn back by a sudden renewal of activity in the neck muscles. Movement, in this case, is evidently not synonymous with motor activity, for it is due to intermittent activity; whereas, when activity in the

muscles of the neck is constant, as it normally is, there is no movement of the head.

Certain common forms of activity often overlooked by the general observer.

With this distinction in mind it will be recognized at once that every waking individual is intensely active, whether he is moving about or remaining in a single position. We commonly recognize that a waking person is receiving sensory impressions, and that he has some degree of consciousness which must be paralleled by central nervous activity. It is the purpose of the present discussion to bring out the significance of the fact that a waking individual is always active. The evidence for this can be produced by recounting the results of certain experiments which show that motor activity is constantly undergoing change whenever an individual is receiving impressions or whenever the consciousness of impressions is present. One of the simplest tests which can be made is a test of muscular strength by means of a dynamometer. If such a test is made in a dark, silent room, and a second test with the same person is subsequently made in a room which is well lighted and full of sound, it will be found that more work can be done in the latter case than in the former. The additional light and sound have raised the nervous and muscular tone to a higher level, so that when the movement is undertaken, the motor impulses to the muscles have the advantage of the higher initial tension. It need hardly be pointed out that the conscious experience of the reactor is different in the two cases described.

Flexor and extensor movements related to characteristic attitudes.

A second experiment is as follows: Let a person be trained to make a certain arm movement of given length with his eyes closed. If a number of measurements are made, it is possible to determine with great accuracy the range of error of these movements under conditions where there is no special excitation. The movements made under such quiet conditions will not be of exactly the same length in successive trials, but they will not differ widely from each other. After these preliminary tests, let the reactor be given a strong bitter or sweet taste sensation. The result will be that the arm, in common with the other muscular organs

of the body, will take on a different tension. The tension in the case of a sweet stimulus will tend to favor outward expansive movements; the tension in the case of a bitter stimulus will tend to favor inward contracting movements. These changes in tension will appear in the fact that the reactor will make, on the average, longer or shorter movements than he did in the original series, although his effort and intention are aimed at uniformity of movement. In all these cases, the reactor estimates his movement in terms of the effort which the movement costs him. Every change in the tension of his muscles changes the effort which is necessary to execute a movement that will satisfy his judgment and seem to him equal to the one which he learned during the practice series. The change in tension which results from the reception of the stimulus disturbs the regular estimation of the movements.

Changes in circulatory movements parallel conscious changes.

One of the systems of muscles which is most noticeably affected by any change in stimulation is the system in control of the circulatory activities. If a recording apparatus is so adjusted as to give a record of the rate and intensity of the heartbeat, it will be found that there is a constant rise and fall in the rate and intensity of circulatory activity. The rise and fall can be shown in striking degree by using in the course of the experiment some marked stimulus, but even when no special stimulus is applied to the organs of sense, there is a continuous flux and change in the circulatory activities. Here again, it is unnecessary to point out that consciousness is constantly changing, and that it changes most noticeably with the application of an external stimulus. Indeed, so close is the relation between activity and sensation in this latter case, that it may safely be said that there is never a change in sensory excitation without a parallel change in circulatory activity.

Changes in motor activity accompany subjective changes.

The cases cited up to this point have been chiefly cases in which some change in sensory stimulation was introduced. Changes in muscular tension appear, however, when the change is one of a more central type. Thus, let a person think of agreeable or dis-

agreeable memory images, let him try to do some mental work, such as solving a problem in arithmetic, and there will be measurable changes in his heartbeat and in the tension of his muscles generally.

Involuntary hand movements reflect subjective changes.

Let the person to be tested rest his hand on some recording apparatus which moves with very little friction. A board suspended by a long string and carrying a tracer at one end is a very good apparatus with which to make this experiment. Now let the subject close his eyes and think intently of his hand. The recording point will make short excursions back and forth, for there is no such condition as one of absolute rest of the hand muscles, and under the conditions arranged, very slight movements are sufficient to produce a record. After noting the range and kind of movement which will be made when one thinks as steadily as he can of the hand, let the reactor think intently of some object at his right or left. Let him make an imaginary journey or draw in imagination some simple geometrical figure. The result will be that the movements of the recorder will be radically changed. There will often be a tendency for the new movement to take on a form directly related to the new subject of thought, but in any case there will be a change from the type of movement which appears when attention is concentrated on the hand, even if the tendency of the new movement is not directly traceable to the new experience. Figure 49 shows the records of involuntary hand movements of the type described.

Such movements as have been described are typical.

Examples could be multiplied without limit to show that every change in experience, whether it is initiated by a change in the sensory stimulus or by some internal cause, is accompanied by changes in muscular tension. Such changes in tension are usually general in character; that is, they are widely distributed throughout the body. There may be certain particular points in the muscular system where the change rises to greatest intensity, but this particular point of emphatic response is included in the general system, the whole of which is involved to a greater or less degree.

Motor processes and attitudes in consciousness.

The significance for psychology of these facts of bodily activity and movement cannot be overestimated. The movements and tensions are not in most cases subject-matter of consciousness; they are the physiological expressions of a nervous organization which is at once the condition of the bodily activity and of the individual's conscious experience. Suppose that the color yellow strikes an observer's eye. It excites a certain sensory process which is carried to the central nervous system. Here the sensory process enters into relations which give it value and significance. We cannot trace these relations in the central nervous system, because they are so intricate and so inaccessible, but we can show that yellow causes a change in the muscular tensions, sometimes producing a change in the rate of the heartbeat. The question which arises at this point is, Are there any phases of experience which correspond to this active side of bodily life, in any such way as sensory quality and intensity correspond to the excitation of the organ of sense? In answering this question, we have reached the point in our study of experience where it is appropriate to call attention to a phase of experience which is entirely inexplicable in terms of sensory quality. We are all

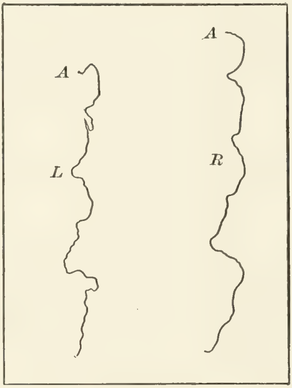

Fig. 49. Involuntary hand movements made by the right and left hands of an observer who is thinking of a building situated in front of him. The hands begin at the two points A, A, the building lies in the direction of the movement which is here represented by the downward extension of the two lines. From Jastrow.

conscious of certain mental attitudes which we assume toward the objects about us. When one sees yellow, he is conscious of more than the mere color. The color arouses in him a response, an individual attitude. This attitude has a certain intensity and a certain character distinct from the sensation to which it attaches. It is not the sensation, but one's reaction to the sensation. This active attitude in experience is intimately related to the individual's disposition to respond to his impressions with a bodily response of some kind. The single word "attitude" may very appropriately apply to both the bodily reaction and the mental process. If, in the course of an individual's experience, there has been developed a violent attitude of dread for a certain group of sensations, there will invariably be developed a bodily shrinking to parallel the mental attitude. The muscular activities at the surface of the body are not the direct conditions of the attitudes in consciousness any more than the peripheral processes in the retina or organ of Corti are the immediate conditions of conscious sensations. The central processes which determine the motor discharges into the muscles are the immediate conditions of attitudes, just as the central processes in the sensory areas are the immediate conditions of sensory qualities in experience.

Space as the form of all active attitudes.

The way was prepared in the last chapter for such considerations as these. It was shown that the orderly arrangement of sensory qualities into a spatial series is not determined by the qualitative character of sensations as they are given in experience, but rather by the way in which a practical series of responses is worked out in the course of the individual's effort to use his sensations in the adjustments of life. The practical development of experience leads, however, not merely to the arrangement of these experiences in certain series; it leads, also, to the cultivation of certain regular modes of personal relation. Very early in life the child begins to realize the distinction between impressions and his personal attitudes toward the world of impressions. The attitudes he learns to treat

as purely private, while the impressions he recognizes as phases of experience which he has in common with others. An attitude is never fused with sensations in any such a way as sensations are fused with one another. An attitude is never arranged in space along with sensations; an attitude is never attributed to a thing along with its other sensory qualities. An attitude may be arranged in a temporal series, for it may itself exhibit change while its object remains permanent; or, conversely, it may remain the same while its object undergoes noticeable transformation. The attitude which one assumes toward things is, accordingly, a distinct subjective fact, separable in introspection from the sensory content to which it is applied.

Attention as a general attitude.

The most general attitude in mental life is one of concentration upon certain factors of experience and rejection of others. When the impressions from the world pour in upon an individual, he does not receive them all with equal eagerness. Some are neglected, others are made the objects of the most vigorous response. Without attempting to describe what the character of this response is, we use a general term to describe the fact that the individual reacts vigorously upon experience; we say that he attends to certain of these experiences and does not attend to others. Attention is not a new factor or content or form of arrangement in experience; it is rather an individual attitude. Attention is not something which is determined by external conditions. The individual attends, because of inner impulses. To be sure, attention and sensory processes are intimately related. Sometimes the sensation seems to attract the individual, because of its intensity. But there is abundant evidence that the individual may neglect the strongest impression, provided he is sufficiently preoccupied. The strong impression is a favorable condition for attention, but the act of attention is an internal response. Very often the internal character of the response is clearly shown by the fact that attention is concentrated upon a sensation of inferior intensity. Again, attention may be concentrated upon the search for some content not

now present, as when one listens for an expected signal or seeks to recall a forgotten name. The character of attention in such cases is very difficult to define in terms which refer merely to the contents of experience. The whole matter becomes clear, however, as soon as we consider the relations of all these cases to the reactive side of experience and of nervous organization.

Simpler cases of attention show their clear relation to motor processes.

No better illustration of this formula could be found than the bodily and mental behavior of a child or an animal. Whatever is attended to in either of these cases is the subject of immediate bodily reactions in the same degree as it is the subject of intense consciousness. The animal absorbed in the pursuit of food concentrates his whole active being so as to give prominence to the sensory and motor processes involved in getting food. All the sensations from surrounding objects, and all the activities which do not contribute to that end, form simply the general background for the one leading fact of individual reaction which centers about the sensation of food and the application of bodily activity to the demands created by that sensation. In like fashion, a child cannot be attentive to an object without seeking to move toward it and grasp it. Attention is here seen in one of its simplest and most direct forms. Similar statements may be made regarding adults. No man ever gave attention without giving active signs of the concentration of his bodily activities on the object of his attention. The fixation of the gaze on the object of visual attention, the set muscles of the face, the suspended respiration, are all marks of attention. Relaxation and attention are terms which do not belong together. Strain, tension, effort, are terms which describe the attitude of attention.

Attention coextensive with consciousness.

So general is the term attention that it has always been difficult to disentangle it from the concept of consciousness as a whole. The reason for this difficulty appears from our foregoing discussion. Attention, in some degree, is present wherever an individual is assuming an attitude toward his impressions. There may be foci of high attention, or there may be a scattering of

attention over a wide field without emphasis of any special contents. The degree of attention may then be reduced until it seems to approach the vanishing point. When all these different degrees of attention are taken into account, there is no distinction between the range of attention and the range of organized experience. The conditions of both attention and consciousness are the same. The only motive for distinguishing between the two is that the general term consciousness gives us a name for the fact that wherever sensory impressions are received and made the basis for reactions, there is some experience, while the word "attention" refers more especially to the selective character of the organizing process, whereby one particular group of sensory factors is emphasized more than any other group and is made the center of organization and the special occasion for a highly emphasized action and a pronounced subjective attitude.

Training of attention may specialize and limit experience.

The contrast between the terms consciousness and attention may be made clearer by asking whether the training of attention in one sphere of scientific observation or in one line of literary study tends toward a general training of consciousness. Certainly, a course of study in any line will add something to the content of mental life, and thus contribute to a richer consciousness, but it does not add in every case to the breadth of attention. Attention, as we have seen, is selective, and repeated concentration on one particular body of material may tend to make attention in any other direction more and more difficult. Thus, the man interested merely in physics may pass over without any attention the plants and animals which interest the botanist and the zoölogist. One can say that the physicist thus trained to look for only one class of facts has little attention for plants and animals. To be sure, even this case shows the relation between general consciousness and attention, for it is clear that even a low degree of attention must be recognized in the general study of consciousness. The case furnishes an opportunity to draw a contrast between the terms consciousness and attention by saying that the physi-

cist is training one type of attention at the expense of other forms of conscious experience.

Animal attention highly specialized and restricted.

The tendency to specialize, which is thus expressed by the word "attention," is strikingly illustrated in the life of animals. Not only is attention obviously related to action, as pointed out above, but the range of attention is definitely limited by the individual's organization. There is little surplus attention for objects not directly utilized in the animal's struggle for existence. Thus, no animal ever looks at a landscape for the sake of enjoying its lines and colors; attention is too much absorbed at that level of life in looking for enemies and food.

Human attention capable in some cases of general training.

In human life, as contrasted with animal life, the limiting influences of specialization are, to a great extent, counterbalanced by the fact that an individual who has once organized experience in such a way as to exhibit close attention in a given direction, seems to be able on later occasions to work his way through a new series of problems with greater ease. For example, a person who has been trained to observe plants, will, if he turns to the task, observe animals better as a result of his training with plants. The explanation of this broad ability to specialize in a variety of directions is undoubtedly to be found in the fact that in human life there have been developed a system of active responses which are at once definite and general in form. This system of responses constitutes what we call language. With the animal all responses are direct and specific, and attention is always developed in the direction of limitation, rather than generalization. With man there are undoubtedly many limiting forms of organization and attention, but there is a tendency in forming words to develop a kind of attention and organization which may, if properly employed, counterbalance the limitations of specific reaction.

Language a most important special form of functional activity.

The problem of the origin and function of language is one of the most important special problems of human psychology. Language and the developed forms of attention which attach to it will be taken up in a later chapter. It is enough to make the relations of this

problem clear at this point. Language is so important a form of activity that human consciousness may be said to be determined in general character and especially in its types of organization, more by the ability to respond to impressions by movements of the vocal cords than by any other motor ability whatsoever.

Attention a general term for phases of organization.

Enough has been said to make it clear that attention is merely a name for various phases of selective arrangement within experience. The further discussions of the organization of experience may, therefore, all be regarded as discussions of attention and will serve to define in full what the term means.

Feeling as a general and as a technical term.

We turn to another general term which has often been used in psychological discussions and in popular parlance as vaguely synonymous with the term consciousness. This is the term feeling. The discussion of this term has been further complicated by the fact that many psychologists use it, not in the vague general sense above indicated, but in a technical sense to designate a group of phases of experience which are sharply distinguished from sensations and from forms of perception. Examples of experiences included within this technical meaning of the term are pleasurable and unpleasurable experiences.

Feeling is a name for personal attitudes.

The various uses of the term feeling all have this common characteristic; they refer to a purely personal phase of experience, to the side of experience which is recognized as made up of one's own attitudes, rather than to the side of experience which is made up of impressions, especially impressions from outside of one's own body. Where the word "feeling" refers to content factors, even these are thought of as intimate personal states, rather than experiences in which reference can be made to external objects. Thus, when one says that he feels cold, it may be that his experience is filled with sensations, but these are sensations of one's own condition, rather than sensations referred to the objects from which they are derived. Again, when one uses the word "feeling" to express the pleasure which he experiences in the contemplation of a painting, he distinguishes between the object at which he is looking

and his own feeling about the object, his feeling being his personal attitude toward the thing seen. When one says that he feels well and begins the day with a buoyant attitude, he does not consciously refer his experience to his organic sensations, even though analysis may show that his attitude is due to a current of stimulations from his internal organs. The fact which he expresses by his use of the word "feeling" is the intimate personal character of the experience. When one experiences a vague dread without being able to explain it, he says he feels a premonition of evil yet unknown. Again, when he reaches a conclusion without being clearly conscious of the evidences, he says that he feels sure or feels doubtful of his ground. All these cases show a lack of reference to content, or they show a vagueness of content which emphasizes the attitude side of the experience. Some writers have made the misleading remark that the feeling itself is vague. This is a confusion based upon the truth that the sensory content of the experience is treated as negligible. Can any one who feels downcast admit that the feeling is vague, because he cannot justify or explain his mood? Obviously not. The feeling is vivid in its own proper character, but not in its accompaniments of sensations. Indeed, the more vivid the feeling phase of any experience, the less clearly will the content factors be apprehended.

Feelings undoubtedly the predominant phases of experience in the early stages of development.

Such considerations as these make intelligible the positions of certain psychologists who have held that feeling is the original and primitive form of consciousness. As consciousness has developed, they point out, discriminations have been worked out and sensation factors have been clearly marked off within experience, and the consciousness of things has been organized into a coherent system. In support of this position, they call attention to the fact that the infant has little clear knowledge, but apparently much vivid feeling. Feeling is, therefore, they contend, the form of consciousness which characterizes the individual while he is at the instinctive level of life and nervous organization. The fact that immature beings are supplied

with marked instinctive attitudes, wholly unjustified by personal experience, but vivid because provided for in fully developed congenital motor structures, lends strong support to the view that feeling is not a content phase of consciousness, derived through contact with the world, but a pure attitude determined by internal organization.

The explanation of feelings must refer to motor processes.

A comprehensive formula embracing all the varied facts included under the general term feeling was first offered by two writers who called attention to the relation of feeling to bodily activity. Lange and James, working independently, came to the view that feelings can be accounted for only by reference to bodily expressions. Bodily expressions are not to be treated as remote and accidental consequences of feelings, but as essential conditions. We do not cry because we are sorry, said James; "we feel sorry because we cry." The feeling is not a mental state remotely accompanying the act, but act and feeling follow upon the stimulus in the order given; namely, first the act and second the feeling, the feeling being the conscious parallel of our organized mode of response.

Feelings are not related to sensations of movement, nor to certain other phases of motor organization.

When the James-Lange theory was first stated, it was the subject of much criticism. It must be admitted that the first statements of the theory were somewhat crude. So strong was the tendency in psychological thought at that time to look for the source of all forms of consciousness in some kind of sensations, that James clearly described feelings as due to the stream of sensations flowing into the nervous system after the expressive movement had been executed. It has been shown in a great variety of ways that the statement in this form cannot be accepted. Thus, it has been shown that the muscular contractions accompanying a feeling take place in time after the consciousness of the feeling has been fully established. The account of the exact nature of the relation which holds between feelings and activities was, therefore, in need of revision, even after the first statement of the general fact that such a relation exists. That such a relation exists and is of prime importance has become clearer

and clearer with the further consideration of the matter since James and Lange first propounded their theory. Indeed, the suggestion made by these two writers is so productive that the present difficulty in describing the conditions of feelings is of an entirely different kind from that which existed at first. We have been led to recognize that not only feelings, but a great many other phases of experience, are related to bodily activity and are explicable in terms of activity rather than of sensation. The difficulty now is, not in believing that feeling is directly related to activity, but in finding out what particular characteristics of motor organizations will explain the special characteristics of the different phases of consciousness which are related to activity. Thus, we have seen that space is the form of arrangement which grows out of the organization of sensation complexes under the requirements of the mechanical possibilities of movement. Attention is related to the selective emphasis laid upon a given impression through the development of an appropriate response. The unity of our percepts is determined by the necessity of combining the disparate factors of sensation into objects of single reactions. What, then, is the characteristic of motor organization which conditions the rise of feeling attitudes, such as pleasure and displeasure, and why should the word "feeling," which is applied specifically to agreeable and disagreeable states, be used at times to designate the other phases of consciousness popularly included under the term feeling and illustrated in a foregoing paragraph?

Feeling is conditioned by relations of harmony between active tendencies.

In seeking an answer to these questions, we may note, first, that feeling in its relation to bodily activity always reflects the harmony or lack of harmony of active tendencies. Every active response which we attempt to make is either impeded or aided by the natural organization of the nervous system, or by other active tendencies present in the nervous system at the same time. So long as the various tendencies toward action which are present at a given moment contribute favorably to mutual progress, the feeling tone of experience will be agreeable; as soon as active

tendencies conflict, they will be accompanied by a disagreeable feeling. This broad general statement will be clearer after considering certain particular cases.

Disagreeable feeling is due to a conflict of motor tendencies.

Take the case of a person who is trying to read and hears continually sounding in his ears a noise calling him away from the book. The tendency to respond to the visual stimulations, as exhibited in the active fixing of the eyes on the printed page, is in conflict with the tendency to answer the noise, and the person is conscious of a conflict in his experience. The conflict may be analyzed and may be made the subject of knowledge and thought, but quite apart from this analysis and thought about the conflict of tendencies, there is in experience a disagreeable feeling which is the conscious result of the conflict. The feeling is not a content factor, as are the noise and the printed words; it is rather the experience of restless wavering between contents. It is the characteristic consciousness of inability to settle down to one kind of attention; it is an attitude of effort to secure an adjustment which seems to be just beyond reach.

Pleasurable feeling is due to coöperation of motor tendencies.

Contrast with this feeling of conflict and unpleasantness, the attitude of another person with entirely different active tendencies in the presence of the same noise. Let us suppose that this second person is actively engaged in making all the noise he can. He will welcome the support which comes to his plans and experience from the disturbance that was so unpleasant to the reader. The experience of satisfaction in the second person cannot be explained, any more than could the experience of dissatisfaction in the first person, by the quality or intensity of the noise. In both cases, it is a matter of personal attitudes. The whole trend of activity in the noisy individual is congenial to the further reception of sound impressions. The more sounds there are, the more easily the response which he is making can be continued and increased. It requires no analysis on the part of the individual to accept the sound as a congenial addition to his experience. The sound fits into experience and contributes

to it; the attitude of the individual's mind is reënforced and encouraged; all this expresses itself in a feeling of pleasure.

Agitation and its attendant feelings may come with new stimuli, for which there is no natural response.

There are other types of motor organization, less temporary than the one which has served for the first illustration. Thus, the organization of certain animals is such that they are aroused by certain colors to a degree of muscular activity altogether out of proportion to the intensity of the sensation. The bull is proverbially much disturbed by a red flag. The activity and feeling tone attached to such a sensory quality are due to the inherited nervous organization of the whole animal. This powerful herbivorous animal, spending its life in an environment which is predominantly green and variegated, at most, only by certain mild color tones, is aroused to violent muscular activity and internal excitement by a color so diametrically opposed to green as is red. Red is strange, and in conflict with all the peaceful attitudes of the animal. The attitude of the animal is much like our own attitude when we hear a strange sound or see a strange form which does not fit into the ordinary routine of life. In all these cases, there is a deep-seated conflict between the normal modes of behavior and the demands of the strange stimulus. Often the agitation and conflict are so great that the sensation factors in experience receive no clear attention, because consciousness is so full of disturbed attitudes. Experience is, accordingly, vague on the content side and violently agitated on the attitude side.

Sensations may have certain feeling tones attached to them by virtue of the general motor organization.

Human responses to different colors are different, according to the changes in quality. The phrases "soothing" and "exciting" have always been used in connection with different colors to indicate the feeling attitude which they arouse. If a careful record is made of certain of the internal activities, such as the heartbeat, it is possible by using extreme variations in color quality to demonstrate changes in the rate and intensity of the heartbeat. These demonstrable facts indicate the presence of many other changes which are too delicate or inaccessible to be exhibited

directly. The feeling tone, or value to the observer of the different colors, is related to these activities, not because the activities are reported back in the form of vague sensations of movement, as James put it in his earlier statements, but because the effect of a stimulus on the individual is to arouse an active tendency which is quite as much a part of the individual's nature as is his ability to receive sensory impressions. If the type of organization is one which allows the stimulus to stir up the individual and keep the motor channels in a state of irregular activity, the color will not only be red or yellow; it will also be exciting. If, on the contrary, the color arouses no general agitation, but tends to reënforce the normal organic processes, its effect on consciousness cannot be fully described by reference to its quality; it will be, not merely green or blue; it will also be soothing.

Those sensory experiences which are described as feelings are related to organic adjustments.

Such considerations as these show why any vague sensory experience which has its chief effect in arousing or retarding activity is described in ordinary language as a feeling. Temperature experiences, for example, have their chief significance in the organic adjustments which they arouse. We do not recognize these adjustments as separate facts, but we are conscious of the general effect which any change in temperature produces in the whole background of activity. Again, the contrast between smoothness and roughness in tactual surfaces is primarily a sensory contrast, but it is not recognized so much through an analysis of its qualitative or intensive characteristics as through the attitude into which it throws one. A smooth surface calls out a regular, continuous movement and a tension of the muscles of the skin, which is regular and continuous. Roughness is a succession of jarring, unrelated impressions, and calls out an irregular and conflicting series of responses. The chief effect of the experience is to arouse a restless feeling of irregularity, and this is due, not merely to the sensations, but also to the type of response which they arouse.

There are certain cases in which the sensation is, from its very nature and because of its general relation

Certain sensations have, from their very nature, necessary feeling relations.

to all life, agreeable or disagreeable. Thus, we are unable in our general bodily organizations to endure great heat. The nervous system developed in a body, which can be kept alive only in moderate temperatures, is so organized that the approach of certain degrees of heat sets up a tendency to draw the body away from the source of the heat. If, for any reason, this natural tendency is impeded, or if the stimulation is so strong that it calls out the tendency in an abnormally intense degree so as to break violently in on the course of ordinary life and behavior, the sensory stimulus will give rise to an experience which is not merely a sensation of heat; it is also distinctly disagreeable in character. It is not an adequate explanation of this disagreeable experience to say that the stimulus endangers the life of the tissues, for the disagreeable feeling precedes by a long range the actual destruction of the tissues. The sensation must be recognized as having a functional value determined by the whole organization of the individual, and this functional value is related to the reaction side of the individual's nature, as much as to the receptive side. Indeed, the receptive organs may be in normal functional operation, while the reactive organizations are engaged in responding to the stimulation with violent protective movements. The character of experience will depend, in such cases, not on the sensation qualities or intensities considered as isolated facts, but rather on the natural tendency toward reaction. The true significance of protective activities is that they conflict with all the normal tendencies of behavior. They are so imperative in character that they conflict with every other mode of behavior and disturb all other forms of attention, thus giving experience that particular tone which we describe as a disagreeable feeling.

For like reasons, sensations from the abdominal organs are usually designated as feelings. Such sensory processes are always present and always enter into every organization, either furnishing a favorable background for the active tendencies of the moment or conflicting with the tendencies aroused in response

Organic sensations are called feelings, because their chief function is to furnish a background for active organizations.

to the demands of the external world. In either case, there is the closest relation between activity and the persistent sensory impulses which come to us from our own bodies. The case is even clearer when these organic processes become abnormal and especially intense; they are then sources of very vivid feeling attitudes. They dominate experience, not merely by their intensity, but also and chiefly by the effect which they produce on the active life of the individual. A man with a toothache or a dull pain in his abdomen cannot pay attention to anything except this persistent impression, which challenges constantly his efforts to remove the irritation and mockingly recurs to interfere with every form of activity until the pain shall be removed.

Attitudes often precede differentiated sensations.

We are now prepared to criticise the doctrine sometimes advanced, that the simplest and most primitive forms of experience are pure feelings. The simplest forms of experience are probably not made up of sharply differentiated contents. The various sensory qualities which enter into these primitive experiences are probably more like our organic sensations than like our visual and auditory sensations. The activities, on the other hand, by which one of the lower animals responds to its vague sensations, are often very definite and well developed, because they are inherited as complete instincts. A sensory stimulus cannot lead, in such cases, to a clear sensation, because the nervous conditions necessary for clear sensation are lacking. If the animal has an experience, it must be predominantly of the type known in our experience as attitude. We may assume, accordingly, that experience probably develops on the side of attitude into clearly marked types before it becomes clearly differentiated in its sensory contents. We should not conclude from this that all forms of feeling are to be looked for in primitive experiences; the few which are probably present, however, give consciousness its character. The statements made regarding consciousness in animals may be repeated with reference to the experience of infants, and even with regard to certain immature

experiences in adults. An infant's instinctive modes of response seem to develop long before its analysis of sensations. The infant shows all the bodily signs of pleasure or pain at a period when it gives no signs of ability to recognize the sources of its pleasures and pains. Experience at such a stage must be predominantly made up of attitudes or feelings. In similar fashion, an adult spends a whole day feeling dejected or happy because of some trivial happening in the morning which is utterly forgotten as content of thought, but was sufficiently decisive in character to influence the active tendencies for the whole day. In some such sense as this, it is doubtless true that experience has well-defined attitudes or feelings before it has well-defined sensations and percepts. It is not true that experience begins with mere feelings, or that it is ever without content factors. It is not true that feelings are at first substitutes for content factors. Feelings are unique phases of experience which depend for their character upon the congruity or incongruity of the different active tendencies of any given moment; they are attitudes, never to be confused with contents.

Feeling is relational, as contrasted with attention, which is selective.

This description of the character of feeling may be made clearer by noting that, while attention refers to the selective aspect of organization, feeling refers to the relation of one tendency to the sum total of active tendencies. While attention ignores for the moment those phases of consciousness which lie outside the focus of experience, the term feeling gets its best illustration in those cases in which the difficulty or ease of providing for a given mode of activity is clearly marked, because the central, selected tendency is favored or opposed by all the tendencies of the moment, especially those which lie outside the focus of attention.

Feelings are "subjective" or personal, as contrasted with sensations, which are "objective" and impersonal.

Feeling has been defined as the subjective side of consciousness in contrast to sensations which are the objective factors. This distinction calls attention to the fact that feelings are matters of purely personal organization, while sensations are never fully determined either in character or time of appearance by individual modes of organization. Of course, sensations and

feelings are both phases of consciousness and, consequently, they are both elements of subjective life, but the feelings are recognized as dependent on the organization and habits of the individual to a much greater extent than are the sensations.

Æsthetic appreciation a form of feeling.

Æsthetic appreciation is a phase of experience which is made up largely of attitudes. When one enjoys the graceful curve of a drawing or its symmetry, or when he is delighted with rhythms, his experience cannot be explained merely by referring to the sensations involved.

Efforts have been made to explain such appreciation through sensations

An effort has been made by certain writers on æsthetics to explain the simpler forms of æsthetic appreciation by the sensations which enter into them. Thus, it has been said that curved lines are more agreeable than irregular lines, because the natural path of an eye movement is a curve. The sensations derived from curved lines are thus supposed to agree very closely with natural tendencies in the organ of sense. Again, rhythm is more agreeable than an irregular or monotonous series of stimulations. This is sometimes explained as due to the natural tendency of the nervous system to exhibit a succession of rhythmical waves of activity and relaxation.

Æsthetic feelings cannot be explained by sensations.

Photographic records of eye movements seem to show that the natural path of these movements is not a curve, but a series of very irregular directions. The rhythms which are most agreeable do not coincide with the rhythmical fluctuations in intensity which can be demonstrated in nervous action. Indeed, the effort to give a simple sensory explanation of the æsthetic feelings always breaks down. The true explanation involves much more than the single sensation; it involves in every case the comparison of series of impressions and the assumption of an attitude which is usually connected with some definite form of bodily reaction.

Unity and regularity sources of agreeable feelings.

Contrast the series of impressions which go to make up the experience of a straight line with the series of impressions which go to make up the experience of an irregular, broken line. In the first case, there is a plan of arrangement which can easily be apprehended and

can be followed in looking along the regular line. The irregular line, on the other hand, is a succession of changes calling at each point for a readjustment of the observer's experience. There is no unity in the broken line. The reason why the straight line gives satisfaction and the broken line does not, can be understood when the two experiences are thus contrasted with respect to their unity and regularity. The line which permits a relatively simple mode of adjustment involves no internal conflicts and, consequently, is pleasurable, while the irregularity of the broken line disturbs the whole organized behavior of the individual and results in a disagreeable feeling attitude.

Further illustration of pleasure and coördination.

The reason why a regular curve is as much more agreeable than a straight line, as a straight line is more agreeable than a broken line, appears when we consider that a regular curve has not merely unity and regularity, but a certain variety which makes the total experience richer in character than does the rigid uniformity of a straight line. It is difficult to express the matter in terms which will not seem tautologous, for the unity and variety of organized experience is at once a fact of experience and the essence of its agreeable character. The physiological conditions of both the organization of experience and its feeling tone are the same. When a group of sensations issues into a single well-organized channel of activity and gathers into this single system a great variety of factors, it leads to a pleasurable feeling.

Feelings of strain and disagreeable experiences.

If we turn to the more complex characteristics of æsthetical figures, such as their balance and symmetry, we find that we can give an account of certain activities which are related to the feeling tone. Let the observer look at an unsymmetrical drawing, such as that shown in Fig. 50. The long horizontal line with the black figures at its ends is not well supported at the fulcrum given in the figure. The feeling of lack of balance in this figure is directly related to an active tendency on the part of the observer to offer his support to the line as it carries the larger figure, and this tendency to action which is inspired by the figures is accompanied by a

distinctly disagreeable experience, because it is continually ineffective in producing its purpose. Examples of the feeling of pleasure derived from harmonious complexes can be derived from the study of Greek architectural forms. The Greeks recognized the fact that a column with perfectly straight lines is not an æsthetical object. Such a column always seems to be weaker in the center than at the extremities, where

The Greek column.

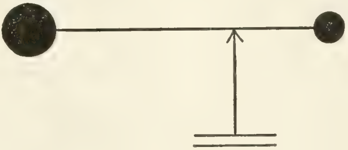

FIG. 50. The two black spots are evidently not well supported by the fulcrum shown in the figure. There is a restless feeling that the large figure should be supported by the observer.

there are larger masses of matter. There is, therefore, a feeling of unrest inspired in the observer lest the column should give way in the center, where the tension is great and the material relatively reduced. The Greeks, accordingly, made their columns larger in the middle than at the extremities, and the result was that the observer, seeing the reënforcement at the critical part of the column, has a feeling of satisfaction rather than of unrest in looking at the lines. The feeling cannot be explained by saying that the eye moves up and down the edges of a beautiful column in any more natural lines than it would if the edges of the column were perfectly straight. The very slight curve in the columns would not produce easy movements, even if if were true, as it probably is not, that the eyes naturally move in curved lines. The beauty of the Greek column, as seen by an observer, can be explained only in terms of a general active sympathy with the column on the part of the observer. The term sympathy is not used here as a figure of speech. There is a real bodily effort

involved in observing a person or even a column lifting a weight. The tension of the muscles often becomes so intense in watching another person at work that the observer becomes conscious of the tension as a distinct fact in experience. In looking at inanimate objects the tension is not so great, but our perception of the column involves an active sympathy which is as important in determining the total character of the mental process as is the complex of sensory impressions.

Illusion of weight shows the presence of muscular tensions.

The presence of muscular tensions related to perception of weight can be demonstrated in certain special cases. If one prepares two blocks of exactly the same objective weight but of very different sizes, so that one is, for example, about a foot cube and the other three inches cube, the observer will find when he comes to lift these two blocks that the smaller block seems decidedly heavier than the larger one. The explanation of this fact is to be found in the muscular preparation of the observer when he first looks at the two blocks. The visual experience from the small block leads him to prepare to do a small amount of work in lifting it, while the visual impression of the larger block is recognized in terms of a totally different kind of muscular organization, which may be described by saying that the observer prepares to do more work in lifting the large block than he prepares to do in lifting the smaller one. When, with these differences of preparation, the observer lifts the two blocks, he finds that his preparation does not coincide with the demands forced upon him through his direct contact with the blocks. There is, therefore, a sharp disagreement between the original percept based upon vision and the subsequent experience dependent on touch. This disagreement expresses itself in the form of an illusion with regard to weight. This illusion is not due to sensations merely, but involves certain preparations or active responses which would never have been explicitly brought to consciousness if the elaborate comparison had not been undertaken. There can be no doubt that whenever one looks at a small object, he prepares to lift it. The preparation consists in an incipient act, and this act

is the physiological parallel of an important phase of the observer's mental process of recognition.

Such muscular tensions common to many experiences.

This illusion of weight and similar facts from practical life throw much light on the nature of the organization which was referred to when it was stated in discussing the æsthetic attitude toward a column, that one sympathizes with the column in the work which it does in supporting the materials placed upon it. There is a certain direct perceptual estimation of the fitness of the column to do its work. That estimation does not express itself in an abstract judgment; it expresses itself immediately in the muscular tension which is aroused in the observer as an integral part of the process of recognition. If the column is inadequate, the observer is led to a strained attitude of assisting the column; if the column is adequate to its task, there is an attitude of satisfied recognition.

Rhythm cannot be explained by reference to simple nervous rhythm.

When we turn from form to the consideration of rhythm, we find, as stated above, that simple explanations of the æsthetic character of rhythms have been attempted on the basis of the fact that the nervous system functions naturally in rhythmical successions. It has been shown in an early discussion that continuous change in nervous processes and in experience is the basis for the recognition of time. It was there pointed out, however, that the mere existence of rhythmical change is not enough to account for the temporal form in experience. The time form can be recognized only when the successive factors of experience, which are slightly different from each other, are bound together into single experiences that are recognized as referring to stable objects, in spite of the changes which go on in mental life. So here, the mere existence of an agreement in rhythmical character between the stimulations and the nervous activities which receive the stimulations, is not an adequate explanation of the feeling of pleasure which is usually aroused by rhythms. We must find some different reasons why a rhythmical succession is capable of giving, not merely a series of experiences, but a series of experiences which are distinctly agreeable.

Agreeable rhythms agree in rate with certain organized forms of behavior.

In seeking an adequate explanation of the pleasure aroused by rhythms, it should be noted, in the first place, that not all successions of a rhythmical character are agreeable. If the rhythm is too slow or too fast, it may become an extremely monotonous succession or a chaotic succession incapable of arousing pleasure. The rhythms of medium rate, which are agreeable, are unquestionably related to the periods of certain forms of coördinated bodily activity. For example, successions of sounds which come at a rate similar to that at which one can make such body movements as are used in dancing, are extremely agreeable. Furthermore, the general rhythms that are favorable to vocal articulations are agreeable, while those which are too fast or too slow for articulation are often very disagreeable. The relation here pointed out is not to the rhythm of nervous discharges into the muscles, for these nervous discharges are far more rapid than the gross movements mentioned. It can be shown, for example, that the discharge of the nervous current into a muscle is at the rate of from ten to twenty waves of discharge in a second. A succession of sounds coming at such a rate would be much too rapid to be regarded as agreeable. A much more favorable rate for the rhythm is one, two, or three strokes in a second, and such rates of rhythm are comparable to the rate of certain bodily activities. We are justified, therefore, in saying that when one is able to respond to certain sensations by movements, either of articulation or of some other sort, there arises in experience a feeling of harmony between the demands of the stimulation and the ability to meet these demands promptly. The feeling of harmony aroused by a rhythm depends, therefore, not upon the fundamental rhythms of nervous metabolism, but rather upon the relation between stimulation and response.

Appreciation always a relational fact.

When we turn from the simpler forms of æsthetic appreciation of symmetry and rhythm to the more complex forms, such as are involved in music and literature, the problem becomes greatly involved. One general principle can, however, be laid down — no form of appreciation is ever determined by the sensation factors

considered out of relation to each other, and out of relation to the individual who is impressed by the sensations. Appreciation is a matter of relations; fiction agrees with life; a figure of speech fits the mood developed in the reader. In all these cases the impression arouses feelings by virtue of its relations.

Attempts have been made to explain tonal harmony as due to processes in the sense organ.

A typical example of the difficulty of explaining feelings by sensation qualities is to be found in the theories which have been advanced to explain the feelings aroused by harmonies and discords in tonal experience. When certain tones are given together or in immediate succession, they arouse a composite experience of consonance which is accompanied by a strong feeling of pleasure. Other tones, when combined, give a diametrically opposite feeling and a distinct experience of dissonance. The physical characteristics of consonant and dissonant tones can be described with great accuracy. The general law is that when the rates of the vibration of tones are related in simple ratios, such as 1:2, 2:3, 3:4, 4:5, 5:6, 3:5, and 5:8, they are consonant and pleasing; while rates of vibrations related in such complex ratios as 15:16 are dissonant and unpleasant. Frequent attempts have been made to find a corresponding fact of sensory fusion depending upon the structure of the organ of sense. Thus, it has been held that the fibers of the basilar membrane are set in vibration by any given tone in such a way, that not only the fiber corresponding directly to the tone is set in vibration, but also certain other fibers which stand in a simple ratio to the fundamental fiber. This series of related vibrations corresponds, it is pointed out, to the external physical fact that a resounding wire or rod gives out a fundamental and a series of overtones, which overtones are related to the fundamental in the simple ratios 1:2, 2:3, etc. It is argued that such a consonant vibration of a number of fibers in the basilar membrane furnishes a physiological basis for the fusion of all tones which stand related in simple ratios, and it has even been asserted that the agreeable character of the consonance is also explained by this fusion.

Criticism of the sensory theory of harmony.

Such a sensory explanation can be attacked from many different sides. In the first place, the experience derived from tonal harmonies is not merely, or chiefly, one of fusion; it is rather an experience of concord or harmony between factors which can be distinguished as sensory qualities. Again, the harmony which is not a sensory fact at all, cannot be explained in terms of the action of the organ of sense except on the assumption that stimulations of the sense organ produce at times sensations of tone, and again, when the tones come in groups, forms of consciousness which are very different from sound. As an illustration of the extraordinary assumptions to which some psychologists have felt themselves driven in attempting to explain harmony, it may be mentioned that certain writers have held that the mind goes through a subconscious enumeration of the vibrations of each tone, and then derives its experience of harmony or discord, and also its feeling of pleasure or displeasure, through a comparison of the numbers thus obtained. Such references to subconscious processes bring only confusion, and are worse than useless in the discussion of experience.

The nervous unity is not sensory.

In view of the difficulties encountered in the formulation of any theory of tonal feeling based upon the quality of tonal sensations, Stumpf, who is one of the leading investigators in this field, has expressed the conclusion that there are certain fundamental unities of nervous activity aroused by harmonious groups of tones, which fundamental unities he frankly admits he is not able to explain.

Some activities related to the recognition and appreciation of harmony.

For the purposes of illustration, we might leave the matter at this point, depending upon our earlier discussions of the relation between feeling and action to suggest the probable direction in which the solution of the problem should be sought. There is one concrete suggestion, however, which may tend to strengthen the general explanation of feeling which has been reached in earlier paragraphs, and at the same time throw light on the nature of the agreeable character of tonal harmony. There can be no question that the ability to produce vocal harmonies through muscular activity

often stands in the closest relation to the ability to appreciate sound harmonies. That there will be a regular law of relationship between the vocal activities which produce differences in pitch, and that this law will be closely related to the laws of physical vibration in the tones produced, is, from the nature of the case, obvious without detailed proof. Again, it is to be recognized that the history of harmony shows that there has been a marked development of the range of appreciation of complex tonal combinations since the time of the Greeks, while there is no evidence of a change in the ear as an organ of sense, but much evidence that there has been a development in the ability to use the vocal cords in more rapid and complex coördinations. Such suggestions as these must be supplemented by reference to the other general activities which have been found to be of importance in connection with the feeling tone of colors and other sensations. The full understanding of tonal feeling awaits more searching examination of the organic activities of the circulatory and general muscular system which are aroused by tonal stimulations. The failure of the effort to develop an adequate explanation of tonal feelings by studying tonal sensations supplies the strongest incentives to take up the general investigation of the activities connected with tonal experiences. At the same time, the discussion furnishes a most striking illustration of the limitations of a psychology which deals with sensory factors alone and neglects functions, especially the functional relations of sensations to activity.

Applications of the theory of feelings.

Such an account of feelings as the foregoing, which shows that feeling and the active attitudes of the individual are inseparably related, gives the largest range to the term feeling, while at the same time it distinguishes sharply between sensory content and feeling attitudes. It also shows the ground of the intimate relations between feeling and attention as expressed in the term interest. Attention is a more general fact and may be seen in cases of both agreeable and disagreeable experience. Since, however, attention is present in high degree in all processes of reorganization

of activities, it is more likely to be intense where the feeling of displeasure shows that certain active tendencies are in conflict, and there is, therefore, a necessity of reorganization.

Functional psychology as contrasted with structural.

The analysis of experience which has been worked out in the last two chapters is distinctly functional in type. There is a disposition in some quarters to reduce feeling and attention, and the other phases of experience, to elements, and to regard them as "structural" rather than "functional" phases of experience. Such reduction of all experience to a common "structural" character makes it very difficult to find any physiological formulas for the conditions of these complex processes of arrangement, and sacrifices the complexity of real experience in the interests of simplicity and uniformity of description. The character of feeling, when it is recognized as a functional fact, may be more difficult to describe in ordinary terminology than when it is called an ultimate element of consciousness, but the more complex formula will be more in keeping with the facts and will furnish a surer basis for the application of psychology to the other sciences of man, and to the practical diagnosis of human interests and forms of conduct.

CHAPTER VIII

INSTINCT AND HABIT

Two sources of nervous organizations: instinct and habit.

In the foregoing chapters reference has constantly been made to the nervous organizations of an individual as important conditions of his experience. No effort has been made, however, to account for the origin of the various types of organization which manifest themselves. The present chapter will be devoted to the consideration of this matter of origins. There are two definite sources from which the organizations in a given individual may be drawn. The first is heredity in the form of instinct, the second is individual effort resulting in the formation of habits.

Inheritance provides the main nervous structures and certain central organizations, also.

Every individual is born with certain main outlines of his nervous structure provided through inheritance, exactly as the other structures of his body are provided through inheritance. If an individual has arms and legs, he will also have the nerve fibers to connect the muscles of these extremities with the spinal cord. The structure of the sense organs is also provided through inheritance, and, as has been made clear in earlier discussions, there is little or no change in the character of these organs of sense in the course of individual experience. Inheritance, however, goes even further than to provide these main structures. The central organs themselves are, to some extent, mapped out at the beginning of individual life. The result of this central organization is that at the time of birth the muscles of the body are not merely under the general control of the nervous system, they are under the control of organized centers which are able, to a certain extent, to coördinate the activities of different parts of the body.

Coördinated activities of the muscles, provided for in the inherited structure of the nervous system, are called

Coördinated activities provided by inheritance are called instincts.

instincts. Good illustrations of instincts occur in the life of any animal and in the early life of human infants. For example, if a young bird hears a loud sound, this sound not only discharges itself through the nervous system, but because of the internal organization of the nervous system, the sound will discharge itself in a group of coördinate activities which result in that form of behavior commonly described as feigning death. The individual bird does not recognize the significance or value of its behavior, at least the first time it executes it. The act can, therefore, not be explained as due in any way to individual intelligence. Furthermore, it appears in the same form in all members of the species. The organization which controls the activity has been worked out in the course of the experience of the bird's ancestors as a form of protective movement to be put into operation whenever the animal is threatened by an approaching enemy. To say that the young bird which performs this movement is cognizant of danger and assumes an appropriate attitude, would be to invert the true relations exhibited in the situation. The mode of behavior is immediate and depends directly upon the external stimulation plus the inherited organization. The attitude of fear is just as much determined through heredity as is the ability to hear the sound through the ear or the ability to respond to the sound with the muscles of the body. The only difference between the structures of the ear and muscles and the central nervous structures underlying the instinctive organizations, is that the peripheral organs are conspicuous and generally recognized, whereas the organization in the central nervous system is inaccessible except through the indirect evidences of activity.

Instincts and primitive forms of experience.

Other typical illustrations of organized instinctive modes of behavior may be drawn from a study of the human infant. One of the most fundamental instincts of the infant is the instinct of sucking. Any young mammal responds to a small object placed between its lips by a complex form of coördination which nature has provided as the only possible means of supporting the animal's life during a period when individual experience

is not sufficiently mature to guide the animal in securing its own food. The form of consciousness which accompanies this instinctive behavior is, of course, a matter of speculation, but it seems highly probable that the experience of the infant is not at all developed on the content side. He is not yet in a position to make any analysis of his impressions or to formulate any definite percepts which may guide him in action. His mental horizon must be limited to an immediate feeling of response to the mass of undifferentiated sensations. Since he is altogether unable to decide in terms of his own experience what he ought to do, the appropriate attitude is given to him by his race and is given in an unmistakable form.

Inherited organizations probably determine many of our mature tendencies.

It is highly probable that the foundations of many of our mental attitudes reach back to instinctive organizations. The arrangement of experiences in space, while it is not worked out in any definite form at the beginning of life, is, nevertheless, partially provided for in certain of the mechanical organizations which we inherit; such, for example, as the tendency to move the eyes so that all bright images shall fall on the foveas. Furthermore, as was pointed out in the discussion of feelings, there are certain stimuli which excite activities that so agree or conflict with natural tendencies as to determine many natural pleasures and displeasures.

Delayed instincts common.

In treating of human instincts the matter is somewhat complicated by the fact that a great many instincts are present only in incipient forms at the beginning of life and are fully matured at a relatively late period. A good illustration of such a delayed instinct is found in the tendency of the young child to walk. That this tendency is inherited is shown by the fact that it will mature, even if there is little or no individual practice. The common development of the young child is a mixture of maturing instincts and ambitious efforts on the part of the child himself and of those surrounding him to hasten the development which would naturally come, even if no exertions were made in that direction. Certain interesting cases are on record which show that children, who for one

reason or another had never made any individual effort to mature this mode of activity, suddenly exhibited it under suitable conditions in a fully developed form. Young animals have frequently been experimented upon in a way to show that their modes of locomotion are wholly instinctive, even though locomotion develops only at a relatively late period in life. Thus young birds, which have been incubated in isolation and have been caged until they reached full maturity, will fly with the natural mode of flight of their species as soon as they are liberated.

Instincts and later acquired forms of behavior are very difficult to distinguish.

If there are instinctive modes of behavior which develop somewhat slowly during the early years of life, it will obviously be impossible to draw a line and say that every form of activity which matures after a certain period is independent of direct hereditary organizations. It is equally impossible to say that the inherited tracts in the nervous system are in no wise modified in the course of individual experience. Indeed, it is always true that on the foundation of inherited coördinations there is built up a system of refinements and modifications, which constitute the characteristic mark of the individual.

Habits from instincts and from independent conditions.

Instincts are sometimes simplified in the course of use; at other times they are united into larger systems of action, or are broken up into their elements and recombined into new types of composite activity. We turn, then, to the consideration of those processes of activity which are related to instincts merely as outgrowths and may, therefore, be treated as the products of individual experience. Those modes of behavior which depend upon individual experience are called habits. In order to make clear the relation of habit to instinct, it should be pointed out that not all habits grow out of instincts. For the purposes of our discussion, two classes of habits may be distinguished. First, there are habits which develop out of instincts. Second, there are habits which develop by a process of selection from among the diffuse activities which appear whenever there is no definite mode of instinctive behavior which serves as a foundation for development.

We may refer to these two types of habits as habits developed from instincts, and habits developed from diffusion.

Development of habit through conflict of instincts.

An illustration of a habit developed from instincts is found in the case in which a child develops a certain definite attitude toward certain animals. This attitude of the child can in many cases be shown to have originated out of a conflict between two tendencies. There are two fundamental instinctive tendencies in every child, indeed in every young animal. It tends, on the one hand, to run away from any strange or unusually intense stimulation. A large object moving toward the eyes, a loud sound attacking the auditory organs, or a strange odor or taste, will stir up in a young animal a mode of action of the protective type. There is, on the other hand, among all of the higher animals, an instinct toward contact with members of the same species and with related forms of animal life. Thus, young birds naturally tend to keep close to any member of their species, and to other objects which are in any way similar to members of their own species. So also do young mammals. Young puppies and young kittens are extremely fond of companionship, and even certain of the more solitary animals naturally herd in packs or in small groups, especially when young. The human infant exhibits both of the two fundamental instinctive tendencies which have just been described. When, accordingly, the child is for the first time confronted by an animal, its reaction may be one of withdrawal or one of friendly contact. Which of the two natural tendencies is actually selected will depend upon a variety of circumstances. If the instinct of flight or protective activity is strong, either because the individual child is disposed to react in this way more emphatically than in the direction of social con*act, or if the instinct of protection is rendered especially pronounced by some accident of excessive external stimulation at the particular moment, then the instinct of fear will dominate, and the social instinct will be suppressed. In such a case, the specialized habit will begin to form in the general direction of fear.

Sometimes the attitude is so thoroughly determined by the first contact with the animal that all through life the individual tends to follow the initial impulse received at the first experience. There are persons who have a very strong attitude of fear for cats and dogs, which attitude has become a fixed individual habit after being selected from among the various possible instinctive modes of response which existed through inheritance at the beginning of life.

Nervous development concerned in the selection of instincts.

The nervous mechanism involved in a habit which has resulted from selection among instincts is relatively easy to explain. We need only to assume that the stimulation which is given at the first experience has two theoretically possible lines of discharge, either one of which would be through a well-defined instinctive tract. The conditions of the first encounter carry the stimulation in question into one of the two instinctive channels and thereafter this selected channel becomes the natural and easy path of discharge for the stimulus whenever it recurs. The habit is, accordingly, dependent upon individual experience only in the one phase which is described by saying that the stimulus is directed into one path rather than the other. The individual does not in such cases cultivate a new type of attitude; he simply applies to the particular situation in hand an attitude which is already present in his nature.

Habit as a modified instinct.

A second somewhat different type of derivation of habit from instinct is found in cases in which the final mode of activity is not along the line of any single instinct, but is a compromise in which one instinct is modified by conflict with other instinctive tendencies. Suppose, for example, that the human infant who naturally tends to be afraid of an animal, is encouraged by circumstances to assume a friendly attitude toward the animal of which he is naturally afraid. His attitude and mode of reaction may be modified to a greater or less extent, so that instead of expressing the full tendency of his instinct to run away, he may have merely a suppressed internal recoil from the animal, while all of his grosser protective movements are modi-

fied. Many of the human instincts are probably thus somewhat reduced in intensity and in their form of expression. Darwin argued at length that the expression of human and animal emotions are in many cases simply reduced instinctive forms of behavior. Many of the facial expressions in human beings are, according to his view, remains of early forms of activity in the jaw and mouth muscles, which once accompanied real combat. The changes in circulation and respiration which come with fear and embarrassment are to be regarded as partial expressions of certain fundamental instincts. For example, when we are frightened there is for an instant a pause in all the internal activities preparatory to the violent activities necessary to flight and after this first pause there comes a violent beating of the heart which originally accompanied flight. When in mature life one refuses to indulge in flight, he may, nevertheless, have all the internal activities. Such examples as these tend to emphasize heredity. The individual is seen to begin life with a large stock of possible habits and instinctive attitudes. His final attitudes are determined in kind and degree by the circumstances of individual life, but the great majority of the fundamental possibilities in human nature are given at the beginning of life. We may say, therefore, that an individual is born with a large stock of attitudes quite as much as with a large supply of organs of sense and forms of possible sensory experience. The inherited attitudes are not specific in their application until after individual experience has worked out the application, but they are native and explicable only in terms that recognize their fundamentally hereditary character.

Diffusion a mark of lack of organization.

Turning now from the habits which are developed through the selection and modification of instincts, we come to the habits which cannot properly be traced to any single instinct or group of instincts. Let us suppose that a stimulus or a combination of stimulations is introduced into the nervous system of the child, but finds no specific channel of discharge open to it through inherited organization. This stimulation will

produce an excitation which will be very widely distributed throughout the whole nervous system, because it has no specific channel of discharge and because, as free energy, it must be transmitted through the nervous system until it finds a discharge into the active organs. The stimulation will, ultimately, issue through the avenues of motor discharge into the active organs of the body, but instead of issuing in a well-coördinated series, it will be distributed diffusely and irregularly and will affect a great number of muscles. An example of the diffuse distribution of stimulation in mature life is seen when one is suddenly startled by an unexpected loud noise, and there follows a general contraction of the muscles throughout the whole body. Such a strong stimulus breaks over all of the bounds of organization in the central nervous system and is distributed diffusely throughout the body. A diffuse distribution of the stimulation is clearly a disadvantage to the individual. The state of the organism after the stimulation is such that the individual is not well adapted to his environment, his activities are not concentrated in any single direction, and he is altogether unprepared to meet the future demands which the stimulation may impose upon him. Furthermore, it can easily be observed that the mental attitude which accompanies such diffuse activity is quite as unorganized as the bodily attitude, and this, also, is an intolerable condition for any individual. The process of modifying such a diffuse reaction, of developing definite and precise attitudes on the mental side, and well-coördinated movements on the physical side, is a long, complex process, carried out by the organism and by consciousness with the delays and complications which appear in every process of natural development.

Habit develops from diffusion through the selection and combination of elements of movement.

If we take a form of activity which has little or no instinctive background, such as the activity involved in writing, and observe the early stages of the effort to develop this type of activity into a habit, we shall be able to observe the characteristics of a diffuse activity. It will be found, first, that movement is excessive both in extent and intensity. The child who is learning to

write moves not only the necessary muscles of the fingers and hand directly engaged in writing, but the muscles of the other hand as well. He also moves the muscles of the face. The diffusion of the excitation throughout the whole organism is one of the most obvious facts to be observed in such a case. In the second place, the elements of movement which are present are not coördinated into harmonious wholes. The various muscular contractions involved in the earliest attempts at writing seldom enter into such relations that there is economy in their several activities. This will be apparent if one observes the way in which the fingers and the hand act during the child's formation of series of letters. There must always be a movement of the hand during writing to carry the fingers across the page. In the child's writing, the fingers are used as long as they can be used without any coöperating hand movement. The hand is brought into play only after the fingers have become so cramped that they can no longer make lines. When this cramping of the fingers reaches such a point that it can go no farther, the finger movement is altogether suspended for a moment and the hand is moved forward in a distinct and relatively separate act. The writing then proceeds as before, the fingers being used quite to the exclusion of the hand. This obvious lack of combined activity of the hand and fingers illustrates a general fact which is also exhibited by the incoördination of the learner's several fingers in relation to one another. The thumb and first finger do not at the outset coöperate with each other in the harmonious way in which they should. For example, at the beginning of an upward stroke, as in the written letter *l*, the first finger presses downward against the pencil or pen more vigorously than is necessary and, as a result, the thumb is called upon to do an excess of work in order to overcome the unnecessary downward pressure of the first finger. There is thus a lack of harmony and even a certain degree of interference in the organs which are directly involved in the activity. The explanation of diffusion and incoördination at the be-

ginning of development is similar to the explanation of the general diffusion of the activity throughout the whole muscular system in the case of a sudden loud noise. In both cases, the nervous impulses which excite the muscles do not follow definite channels. In the case now under consideration the channels are not yet developed, while in the case of the loud sound they are not able to confine the strong discharge to definite paths.

Undeveloped movements are of relatively short duration and are relatively simple.

The third characteristic of an undeveloped movement is one which is closely related to its incoördination, and consists in the fact that the various phases of movement are all of brief duration, not being united with each other into a continuous series. If one examines the writing of a child, he finds that the lines, instead of being continuous, fluent lines, are made up of short, irregular parts. The direction of the movement in these short, irregular parts is very frequently away from the general direction which the movement should follow. We may say that the line is a succession of efforts to produce the line rather than a sequence of coördinated muscular contractions appropriate to the general movement. When the movement develops, as it does after practice, the different elements are bound together in such a way that their sequence cannot be detected; they are no longer separate factors. The adult who begins to write the letter *l* does not make a series of separate movements as the pencil is carried along the upward stroke. He does, however, make a series of muscular contractions. The transition from the irregular succession of separate movements to a series of contractions constituting phases of a single complex activity, which however is thoroughly unified, is provided for by the coupling together of a series of nervous tracts which provide for the proper temporal distribution of the motor excitation.

Diffusion analogous to all forms of overproduction.

It is clear from the foregoing study of the characteristics of an undeveloped activity that nature approaches this problem of development in the same way in which all the problems of development are approached; namely, through excessive productions and selection

of the proper elements. Since the child does not have the proper nervous organization to control his movements, nature has provided that he shall make a superabundance of movements involving all of the different parts of the body, even those which are not directly concerned in the final activity. If, in this excess of movement, certain factors accomplish the end toward which the individual is working, these successful constituents of movement will gradually be emphasized and the unsuccessful constituents will gradually be eliminated, until finally diffusion gives way to a limited number of precise and well-defined combinations of activity. If the selected factors are repeated together a sufficient number of times, the nervous activities involved in each particular phase of the movement gradually become connected with each other. This uniting of the nervous processes and structures when repetition of the activity takes place, is due to the fact that the central nervous system cannot become active in one of its centers without involving to a greater or less extent sympathetic relations with all of the other centers which are in action either at the same time or immediately before and after.

Principles of fusion and selection.

The two fundamental principles of nervous development important for the explanation of habit are, accordingly, these. First, there is a tendency for all parts of the nervous system which are active at the same time to become related to one another in their activity; and, second, there is always a process of selection going forward by which those combinations which attain the end toward which the individual is working are preserved and the others are eliminated. The first of these two principles is not difficult to understand when the close structural and functional interrelation of the various parts of the nervous system is recalled. The second principle is much more difficult to explain. This principle may be restated in the following terms: If an animal goes through a certain mode of activity and derives advantage from the success which attends this performance, it is likely to repeat the activity; whereas, if the activity does not attain

success, the animal will not repeat it. The disposition of the ordinary man in observing such a case as this is to say that the mind, observing the success or lack of success of the movement, decides in favor of a mode of action or decides to abandon it. There are many cases, however, which are not susceptible of this explanation of intelligent choice. For example, animals have been observed under experimental conditions, and their modes of developing habits have been carefully recorded. Thus, cats were put into boxes which could be opened by sliding a simple bolt, or by pulling a string, or by various combinations of these devices. Outside of the box was placed food or other attractive inducement which tended to prompt the animal to execute the necessary movements to effect its escape. The animal showed at first under these circumstances all the characteristics of diffuse behavior, moving restlessly about the cage and clawing aimlessly at everything it could reach. Finally, by sheer good fortune, it hit upon the particular kind of activity which freed it from captivity and put it in possession of the food. After the animal succeeded once in making the successful movement, it was again confined in the box and was induced to repeat the act. The time required for the second escape was shorter, and yet in this second case the animal did not go about the act in any intelligent way. It merely exhibited less diffuseness. The reduction of diffuseness was undoubtedly conditioned in the nervous system by the development of more definite lines of discharge.

Experiments with animals exclude the explanation of habit as the product of deliberate choice.

Pleasure and displeasure attending the selection of successful activities.

The pleasure which an animal or a human being enjoys on attaining what is called success in any given enterprise must be related in some way to the organization which we have been discussing. If the animal is constantly receiving from food placed before it the sensory stimulations which incite it to activity, it will, because of its instinctive tendencies of response to the food, be induced to make the effort necessary to secure the food. If the box is continually in the way of its accomplishing the instinctive action appropriate to the stimulus, it will experience, for reasons which

were pointed out in earlier discussions, a marked disagreeable feeling. When, now, by any chance activity on the part of the animal, the obstructions are removed and the instinctive tendencies to take food are allowed free play, the animal derives pleasure from the consummation of its instinctive tendencies. The stimulation has been discharged through the instinctive channel by first passing through the channels which led to the activities which made the instinctive movements possible. Thus it is that the movements which immediately preceded the instinctive acts are, by the natural process of nervous organization, coupled with the instinctive activities into a single whole. This total combination, accordingly, becomes an harmonious and continuous form of behavior on the first principle stated; namely, the principle of fusion of simultaneous or immediately successive processes.

Pleasure a result of organization, not a cause.

It is too abbreviated a form of statement to say in this case that the pleasure of success leads the mind to select the appropriate activity; the fact is rather that the pleasure comes because the selection has been successfully made in a natural way. When we understand this more elaborate formula, we can apply it to many cases. Thus, the child's pleasure in successfully forming a letter is not in essence different from the animal's pleasure in securing food. The child does not begin to write until there is a strong tendency toward activity aroused in him by the sight of external examples and models, or by the less direct desire to escape punishment. When he finds his activities attaining only in a measurable degree the ends toward which his models and examples attract him, he feels a displeasure which comes from a comparison of his own products with the patterns set for him. When, on the other hand, his movements attain the end desired, there is pleasure. The pleasure is not, as some have believed, the selective factor. The pleasure is an incident to the total process of adaptation. The selection can be explained only when it is recognized that movement is always an adjustment to some exciting stimulation, and is successful only when that exciting stimulation has been

met in a way which is natural and compatible with the total organization of the individual.

Habits cease to develop when the practical motives no longer compel selection.

A further examination of certain negative facts which appear in the development of writing will make clearer the nature of the selective process by which habits are organized. Just as soon as the child's attention in writing is turned away from his models and from the social motives which tend to incite him to greater effort toward the perfection of form, he ceases to select movements which are more advantageous for the construction of legible letters. He now uses writing for more remote purposes and leaves the organized activity in the form in which it was when his attention turned to broader considerations; or, at most, he merely allows easier and more rapid forms to creep in without reference to the effects on the legibility of his writing.

Diffusion is not fully eliminated even in adult writing.

It can easily be shown that there are many unorganized and diffuse phrases in adult writing, which result from the fact that most persons are no longer in a critical attitude toward their own activities. Many persons show that their motor organization is diffuse by moving the head unnecessarily, or by contorting the face in sympathy with the writing activity. Many adults are diffuse in excessive pressure upon the paper on which they write. Such excessive pressure against the writing surface has not been fully eliminated, because the individual has never been driven by obviously unfavorable consequences in his writing to see that excessive pressure is an unsuccessful part of the movement. Again, when attention is given to the relation between hand and finger movements, incoördinations will be observed. Not more than ten out of every hundred writers are able to adjust the hand so as to secure a fairly uniform slope of the letters in all parts of the page. The positions of the hand at the beginning of the line of writing and at the end of the line of writing determine the differences in slope of the letters in these parts of the line, and the tendency to irregularity can be largely eliminated by a rotation of the hand as it crosses the page. This rotation is

very frequently uncultivated and irregular, and, as a result, other hand movements have to be injected into the series of activities in order to correct the uneven slopes, making the total movement of the hand unnecessarily clumsy and uneconomical. These crudities which remain in adult writing show very clearly that the development of habits must always have some definite cause. Selection of movements is a positive process. When the child shows a tendency to select and improve in writing movements, while the adult accepts as finished a form of behavior which shows lack of complete development, the explanation of these facts can be found in the strong motives for development in the early stages of life and the absence of these motives later.

Every organized motor process tends to express itself.

From this discussion of the development of habits, we turn to certain practical principles of organization. When an organization has become thoroughly established, either because it is a native instinct, or through the selection of instincts on the ground of personal experience, or through the development of a habit from diffusion, there is a strong tendency for the developed activity to be used by the individual. The tendency to repeat organized modes of activity shows itself in a great variety of ways. There is, perhaps, no better illustration of this fact than the play activities of children. Such activities are due at first to natural instincts, and later in life to the tendency of an individual to repeat the activities which he has cultivated through personal effort. One cannot observe the behavior of a young animal or child without recognizing the fact that at certain periods of life, when instinctive activities mature, the individual tends to repeat these activities again and again, and at the same time derives great satisfaction from them. The kitten playing with the ball is a typical illustration. The child picking up an object and laying it down repeatedly is an equally good illustration of the pleasure derived from the mere execution of a form of movement which is naturally provided by inheritance. Many of the plays of children express the deep-seated instinctive

tendencies of human nature in immature form. The child enjoys the experience of fear so long as it is sufficiently mild to lead to the mere exercise of his natural instincts of flight, without calling out the instinct in its full intensity. The young animal enjoys the test of strength with his fellows, because this test is a faint expression of his natural instinct for combat.

Pleasure from the execution of acquired habits is as natural as pleasure from instincts.

When we come to the more elaborate forms of play, we cannot account for them merely by the formula of instinctive tendencies. The child who sees his elders working at some form of manual art can hardly be said to have an instinct for the repetition of these activities. Our formula must be somewhat more elaborate in this case. We may say that the visual recognition of the movement tends at first to arouse in the child diffuse motor activities. These diffuse tendencies are gradually refined under the influence of selection in the presence of the model, until they become personal habits. As the vague natural tendency toward action thus develops into a definite habit of movement, the child will derive great satisfaction from the repetition of these movements, just because it is a pleasure to execute a natural form of activity whether it is organized through inheritance or through acquirement. The tendency to acquire and repeat a form of expression is called the tendency to imitate. This tendency is a complex made up, first, of respect for elders and all that this respect implies, and, second, of energy of action in excess of the immediate individual needs, and, finally, of a natural relation between visual stimulations and movements of the limbs. Imitation is not a particular instinct; it is, however, a natural and inherited tendency, for there is a natural disposition in any organic tissue toward action. What is true of organic tissue in general is true of nervous tissue; it naturally responds to stimulation, so that the individual enjoys action. The secret of the pleasure in repetition in play is to be found in the fact that organized activity is the most natural channel along which the impulse to activity expends itself.

The effort has sometimes been made to explain art

in its manifold forms as an expression of human instinct, and there can be no doubt that there is a natural tendency in many arts, as, for example, in music, to express the rhythmical characteristics of native forms of action. Primitive music is attractive to those who produce it chiefly by virtue of its rhythmical character, there being no harmony in the tones which enter into the rhythm. The development of the art in its later stages, however, evidently cannot be attributed merely to instinctive tendencies, because it involves so much more than primitive art. Art grows with the developing ability of the musician and of the listener. As the vocal cords are drawn into action, they supplement the first tendencies which are more closely related to the crude dancing movements and involve only the larger muscles of the body. As the habits of articulation and song develop, the pleasures derived from the execution of musical compositions and the pleasures derived from listening to musical productions increase in proportion to the new habits of expression which are developed and which give pleasure in their exercise.

Artistic satisfaction is both instinctive and acquired.

There is another phase of habits and instincts which it is important for us to consider in this connection. It is a commonplace that the development of a habit frees us from the necessity for elaborate conscious control of the movement which is involved in the habit. No one has to pay attention in mature life to the details involved in the formation of letters as he writes. By long practice he has developed a habit of forming these letters and can now rely upon the nervous organization to work out the details. When one considers a single habit, it appears that the scope and vividness of consciousness diminish with the perfection of development. But we have no right to consider a single habit of action wholly apart from the general development of the individual; and when the general development is considered, we find that the organization of a certain automatic habit may very often be attended by an enlargement of the possibilities of attention, so that when one activity has been removed from the

The center of conscious life changes with development, but consciousness is not reduced.

focus of attention by becoming habitual, it makes place for other factors of experience which now come into the focus of attention. The shifting of attention from a given point in experience to some other, does not, then, necessarily involve a diminution of the sum total of conscious experience. Whether or not the habit shall free the individual to pay attention to higher and more elaborate considerations or to simpler and less significant phases of experience, depends entirely upon the direction in which the development of individual experience tends, not upon the single isolated habit. The scientist who learns to perform a certain movement such as manipulating objects seen under the microscope, has freed his attention for the purpose of considering the objects with which he has learned to deal. The weaver who learns to manipulate his loom so perfectly that it requires relatively little attention, may, on the other hand, spend his surplus mental energy in miserly imaginations or in the contemplation of petty gossip. In the case of the scientist, we have the habit serving an advantageous end and leading to a broader mental development. In the case of the weaver, it appears clearly that there is no inherent necessity of mental development of a broader type through the development of habit. The two illustrations together show that the question of mental development is only partially solved when we deal with habit. Habit is taken up and organized into a larger system of personal consciousness and personal adaptation which will determine the value of the habit and the relations into which the habit is brought.

Percept and habit are direct forms of organization and are to be contrasted with higher forms.

This concludes the discussion of the direct forms of consciousness. Perception with all of its forms of arrangement and all of its attendant attitudes is not the whole of conscious life. There are in man a variety of indirect forms of consciousness which transcend perceptual organizations in complexity and importance as much as perceptual organization transcends sensation. To the consideration of these indirect forms of organization, we now turn.

CHAPTER IX

MEMORY AND IDEAS

ALL of the discussions up to this point have dealt with forms of experience which are directly related to sensory impressions. We have now to consider those phases of experience which are supplied, not directly through sensation and perception, but indirectly through memory. If one closes his eyes and thinks of the scene which a moment before impressed itself upon his vision, he will recognize that his consciousness is filled with a substitute for direct visual sensations and percepts; this substitute is called a memory image. When one thinks of an absent acquaintance, the memory image may contain factors which are substitutes for direct auditory impressions of the voice. When one thinks of a rough surface without touching it, the image contains substitutes for tactual factors and their perceptual organization. These illustrations serve to emphasize the scope of the word "image," which it will be seen is used not merely for vision, but also for all spheres of experience. Furthermore, enough has been said to justify the description of memory images as indirect factors, because it is clear that memory images are related to earlier sensory and perceptual processes and derive their qualitative characteristics from the direct experiences for which they are substitutes.

Memory image.

Before taking up any of the details regarding the character and laws of memory images, it will be well to dwell briefly upon the great advantage to the individual of possessing these substitutes for direct impressions. The mind supplied with memory images is relatively independent of contact with objects; the images may serve as the basis for attitudes and for reconstructive organizations which may be of the

Advantages of relative independence of sensory impressions.

highest significance in individual life. A commonplace illustration of this advantage is seen whenever one runs over in his mind the various places in which he has been and where he might have left a lost object. More complex illustrations may be drawn from the mental activities of an inventor who thinks out many combinations, thus using the images in consciousness as substitutes for real objects. To be sure, there are certain disadvantages which connect themselves with these advantages. The inventor can make more mistakes in this imagery than he could if he tried to fit together real things, and one's false memory may lead him far astray. But taken in the large, the freedom from the necessity of always waiting for direct impressions is one of the great superiorities of the higher forms of mental life.

Individual variations in imagery.

One of the most important statements to be made in the description of memory images is that different individuals show great differences in the character and vividness of their memory images. Some years ago, Galton asked a number of individuals to test their mental imagery by calling up as definitely and fully as possible the familiar objects of the breakfast table. After the memory image had been called up, the observer was requested to state how clear the mental image was in color and form and other characteristics. Some of the observers said that they recalled objects with a vividness and detail altogether comparable to their perceptual experience. These Galton called good visualizers. Others described their memory images as extremely vague and hazy. Still others, who were between the extreme classes, stated that their mental images were restricted in extent and were relatively fainter than the percepts themselves, but, nevertheless, fairly comparable in general character to direct sensory experiences. Galton's tests have frequently been repeated, and his results have been fully corroborated. Furthermore, it has been found that persons who have faint visual images have, in some cases, vivid auditory images. Some persons have vivid tactual imagery or vivid memory of movement sensations. The blind,

for example, must have images of this kind, giving to their memory consciousness a totally different type of content from that which exists in the mind of the normal individual.

The accidents of individual experience determine imagery.

Not only is the type of memory very different in different individuals, but the special contents must differ according to the accidents of individual experience. Thus, if two persons have looked at the same scene from two different points of view, their imagery will be different; certain near and vivid factors for one person will be vague and remote for the other. Then, too, individual attitudes react upon the contents of experience to determine the character of imagery. If an especially pleasing or disagreeable color has been presented to a given individual, it may continue in his memory for a long time, while a second individual looking at the same color, but not greatly pleased or displeased by it, may very soon forget it altogether.

Dependence on vividness and recency.

In spite of individual differences in mental imagery, there are certain general statements which apply to all persons and all types of memory. First, memory depends, all other conditions being equal, upon the vividness and recency of the sensory impression. It should be noticed that memory does not depend on intensity, but on vividness. If intensity results in the concentration of attention upon the impression, then intensity may indirectly help to fix the impression; but a faint impression upon which attention has been centered will continue in memory long after the disappearance of an impression which passes without attention. The recency of an impression is also a matter of importance. Careful quantitative tests show that impressions fade with relative rapidity at first and at a very gradual rate later. We forget many impressions entirely in the first few moments after they are received. What we retain beyond the first brief period is more likely to continue as a relatively permanent addition to the content of consciousness.

The training of memory.

Much has been said with regard to the scope of memory and with regard to the possibility of increasing the scope of memory by training. It is doubtless true

that the ability to retain impressions differs greatly with different individuals; some retaining many impressions and carrying them forward through long periods, others having little or no ability to retain. So clearly marked are these natural characteristics of different individuals that the changes produced through practice are relatively small. Indeed, Professor James asserts that there is no possibility of changing the degree of natural retentiveness through training. This statement has been shown to be out of harmony with the facts, for there are evidences of increase in the scope of memory through training. Nevertheless, Professor James's statement is probably much nearer the truth than the popular assumption that memory can be radically changed through practice.

Retention as distinguished from recall.

Another general fact regarding memory is that experiences are not actively recalled without some present impression or related memory which serves as the motive or occasion for the exercise of memory. The mere retention of an impression is not the whole of memory. For example, at this moment there must be retained by every reader of these words hundreds of proper names. There is no motive for the recall of most of them. If one should find in the text, however, such a phrase as "author of the *Iliad*," one of the proper names would be recalled and memory would become active for that one name. This name might in turn suggest other memories. The fact that memories are thus linked together and that active recall is always a matter of a train or sequence of processes was noticed long ago by Aristotle. He described the principles of memory, or, as they were later designated, the laws of association. There are two general principles of association which we may note: first, the principle of association by contiguity; and, second, the principle of association by similarity or contrast.

Association by contiguity.

When one thinks of the letter *A*, he is very likely to recall also the letter *B*, because the two have so often followed each other in experience. The first line of a poem suggests the second; the sight of one of two inti-

mate friends suggests the other. In general, when two experiences have been intimately related in earlier experience, the appearance of one is likely to serve as a sufficient motive for the recall of the second.

Association by similarity.

When one sees a face which has eyes, or nose, or mouth, like those of another person, the like feature is in many cases enough to recall the absent person. In such a case as this, the two faces now associated need never have appeared together in the past; it is enough that they contain the same feature. This relation between two experiences having a common factor is evidently a more complex fact than association by contiguity, for it involves a sufficient analysis or concentration of attention upon a single feature to separate it from its present surroundings and make it the link of connection with a group of experiences not now present. The diagram in Fig. 51 represents the situation. The circle *A* represents a single feature of the face now seen; *b*, *b*, *b*, are the other features. In a past experience, *A* has been part of a system of features of which *c*, *c*, *c*, were the others. If *A* becomes the subject of special attention, it can revive the elements *c*, *c*, *c*, and thus detach itself from *b*, *b*, *b*, the features of the present complex in which it stands. In general, then, whenever a factor of experience now present has appeared in earlier experiences in a different combination, the earlier combination may be recalled through association by similarity.

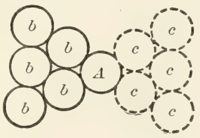

FIG. 51. The full-drawn circles represent the elements of the present experience. Of these elements *A* attaches itself also to the system of elements represented by the dotted line circles. *A*, when taken with the circles *b*, *b*, *b*, constitutes the present experience; *A*, when taken with the circles *c*, *c*, *c*, constitutes the recalled experience. *A* is obviously the center of relations between the two systems.

Association by contrast.

Association by contrast will be clear after the foregoing discussion of association by similarity, for no contrast can exist without like elements. One may

contrast a candle and the sun because they both give light, or the moon and a coin because they are both round, but in each of these cases the basis of the contrast is a common factor.

Organic memory.

The physiological conditions of memory have often been discussed, and attention has been called to the fact that retention is not a unique characteristic of consciousness. Under the term organic memory, almost every form of retention has been discussed. Thus, when the palm of the hand becomes calloused, the skin is sometimes said to exhibit organic memory. A scar is also referred to in the same terms. This use of the word "memory" is justifiable in so far as the word refers to retention, but it is not justifiable if it is intended to indicate recall, which the ordinary man always implies in his use of the term.

Organic memory of nervous tissues.

One application of the term organic memory in which we are especially interested is that which refers to retentions in the nervous system. The structures of the nervous system are, in a very important sense, records of earlier functional activities. Indeed, organic memory may reach back of individual life and record in inherited structures the early activities of the race. Instincts have, accordingly, been described as racial memories. Again, it is to be said that the extension of the word "memory" to such cases is likely to lead to confusion, because, while there is retention in such cases, there is no conscious recall, as is commonly implied in the term memory. The same remark applies to many of the changes in the structure of the individual nervous system which arise during the course of individual life.

Conscious memory in the broader and narrower senses.

The broad use of the term organic memory is paralleled by a broad application of the term memory in the description of conscious processes. Whenever a present experience depends upon past experience, either for its elements or for its form of organization, there is a disposition to speak of the experience as involving memory. If the term is used in this broad sense, there is no conscious process which does not involve memory. Every habit which develops from

diffusion, every organization of sensations into a spatial or temporal series depends upon past experience and brings over into present mental processes the influence of that past. The term memory when thus used becomes synonymous with the whole organized system of active and conscious processes. The broad fact to which the term memory is thus applied is too significant to be overlooked, and yet it is not desirable that the word "memory" be indefinitely extended. We shall, therefore, use the word "memory" in subsequent discussions only in those cases in which phases of experience are recalled from the past and consciously recognized as so recalled from the past. When the term memory is used in this narrow sense, the general facts to which reference was made in the broader use of the term may be covered by the statement that memory processes pass, on the one hand, into habits, and, on the other hand, into more elaborate forms of conscious activity. The recall of past experiences in such a form that they can be recognized as facts of memory in the narrow sense is never a stable form of experience. The reproduction of past experience must always serve some purpose of mental organization, or disappear altogether. It may pass into a form of active adaptation and continue as a habit; it may pass into the higher forms of conscious activity; or, finally, it may fade out. It is probably true, however, that even before it disappears by fading out, it affects the organization of mental life in one of the first two ways mentioned.

Memory merges into habits.

In order to show how memory images tend to merge into habits, let us examine the simple case in which one meets a person to whom he has been introduced on an earlier occasion, but whom he now finds it difficult to recognize. The present impressions of face and form are sufficient to arouse within the observer a tendency toward reaction; there is a vague reverberation of the first experience without any adequate or full reinstatement of the content factors present at the first experience. The present stimulation does not issue on its motor side into any definite form of behavior, but seems to halt at the point of discharge. The

observer feels that he is just on the point of giving the stranger's name, or making the same remark that he made when he saw him before. On the side of imagery, experience does not reproduce fully the conversation of the first meeting. There is consequently a distinct feeling of unrest and dissatisfaction. The nervous mechanism has been partially organized by the first experience, else there would not be the present vague feeling of familiarity; but the earlier organization is not complete, and the present activity is neither so direct as it would be if the organization were complete, nor is it free to adopt some wholly independent direction, as it would be if there were no revived tendencies brought over from the first case. Under these circumstances there will be a tendency on the part of the observer to concentrate on the present stimulus until it recalls by association the first experience. If the earlier processes were sufficiently intense, or if the present effort is continued long enough, there may ultimately be a partial reinstatement of the earlier experience throughout its whole course. The observer will then have not only the present percept, but a more or less complete repetition of the earlier experience to guide his activity. The indirect character of these revived factors will be evidenced by the fact that they cannot be verified by any present sensory impressions. They will also have the marks of their subjective origin in their relative vagueness and uncertainty. The image may, under certain conditions, contain reinstated factors which were not derived from the particular experience which is called for by the present stimulus. The observer may sometimes be at a loss to distinguish between true and untrue revivals, unless there are internal incoherencies between the reinstated factors indicating that some should be present and others not.

Memory image supplements percepts as a guide of behavior.

After the memory image is thus aroused, it is used as a percept would be used to guide action, and so becomes an important additional means of controlling behavior. The control of action is the function of the memory image. If the observer has a second and a third experience similar to that described, he will find

that the memory image can be called up in later cases more easily than at first. He will also observe that there is less and less emphasis on the content factors of the memory image. The slightest revival of the memory image is enough to arouse the appropriate activity; that is, the function of the image is gradually selected as the important contribution to individual development, and the content factors drop out more and more. Thus, after several meetings with an acquaintance, the name is uttered without any elaborate recall of the time when the name was first heard. The recall of earlier friendly or unfriendly encounters is condensed into an immediate friendly attitude of salutation, or the unfriendly attitude of withdrawal. The conversation takes a natural turn in the one direction or the other, according as the acquaintance is a business acquaintance or a social acquaintance. In short, the observer is thrown into a series of active attitudes which constitute his acquired reaction upon the impression which he receives from the familiar face now before him. It is a matter of everyday experience that, as this direct form of response develops and becomes more perfect, the memory contents which were once necessary, disappear entirely. The memory stage of organization may be long, as in the case of a person whom we meet only casually at infrequent intervals, or it may be short, if experience is frequently renewed. But in any case the memory stage is merely a transitional stage, and gives way to habit as its end. Habit embodies all that is useful of the early experiences, for it is not the details of these earlier experiences which we need to guide us; it is much better that we should extract from our successive experiences the appropriate attitudes, and rely upon these as condensed resultants of all our former experiences.

Past experiences contribute to organized forms of recognition.

Such a drifting of memory back to direct perception is the common result of repeated practical contacts with the subjects of memory. When an object is to be handled time and again, when a person is to be dealt with in a direct fashion, then perception must

be organized as compactly as possible, and imagery becomes a hindrance rather than a help; it therefore gives way to direct forms of organization. No better illustration than this could be found of the fact that the development of all experience is in the direction of the perfection of functions. Content is here used for a time to aid in building up a habit and then the content is dropped and the function is retained. The value of memory in such cases as this is merely to enlarge the basis of reaction until the most useful type of reaction can be securely established. The subject, instead of framing his reaction on a small number of present factors, is enabled to base his reaction on the present factors plus those brought over from the past, until finally the reaction is sufficiently refined to be independent of guidance.

Attitude is much more difficult to reorganize than remembered images and their corresponding tendencies.

When experience takes the form of an organized mode of response with its attendant attitude, it is very frequently exceedingly difficult to modify it. The elements which contributed to its organization have disappeared, leaving the present attitude without any content factors to explain its origin. The individual is thus dependent for his interpretations upon his attitude, and this grows more fixed as it is repeatedly utilized. This accounts for the conservatism of most of our experiences. Each individual has his attitudes toward his acquaintances, toward his ordinary forms of experience, and these attitudes have a stability and sanction which no single impression and no single disastrous result of applying the attitude can overcome. This is nowhere better illustrated than in referring to those attitudes which we describe in ordinary life as one's tastes; as, for example, one's taste for certain combinations of lines as seen in works of art, or one's likes and dislikes for colors and for places. These are proverbially not open to question or explanation, and they constitute what may be described as one of the most conservative and characteristic phases of individual character. That tastes are built up on the foundation of individual experience, no one will deny; that they are forms of memory is an asser-

tion which no one would make unless he were prepared to extend the word "memory" to include all organizations within personal consciousness. They serve, therefore, as admirable illustrations of the consolidations of memories into attitudes.

Recognition of words dispenses with memory contents.

Similar statements could be made regarding many other forms of experience. A word is interpreted at first by laboriously attaching to it some memory image. Any one can verify this by attempting to learn a new name. The words of the vernacular with which we have constantly to deal become so familiar and easy of interpretation that no memory images intervene when we use them in ordinary life.

Memory as the basis of elaborate ideas.

Enough has been said to make clear the first type of development of memory images. We turn now to consider the way in which memory develops into the higher forms of mental activity. Every memory image has characteristics which distinguish it from the percepts in which it originated. So different is the organization of memory images from the organization of direct perceptual processes, that we should be fully justified in emphasizing this difference as one of the most important marks of memory. This can be made clear by examining any simple memory image. Suppose that one has been looking at a landscape; the infinite detail of sensory quality has been arranged in experience into a spatial form in which certain points of interest and attention stand out as conspicuous centers. Now let the observer close his eyes. Much of the detail is instantly gone, the remaining memories of sensory impressions do not assert themselves as did the sensations when the eyes were open; they do not seem to compel the mind to give them a certain arrangement demanded from without; they are easily readjusted in response to internal modes of organization. The vast spatial expanse, which a moment ago had such a distinctly objective character, seems to have receded into the individual's inner self; it can be contemplated as a part of the subjective world. The points of personal interest and attention are, even more than in the objective scene, the centers of the whole

organization. In short, the experience of the observer with closed eyes is more subjective in character, more subjective in its emphasis and arrangement of contents, more subjective in its value than was the direct percept. So distinct from percepts are the products of memory that a distinct term is required to designate these experiences. The term idea is perhaps the best English term to designate these indirect experiences. The terms thought and memory image are also used. Thought lays great emphasis on the subjective character of the processes, and memory image lays stress on the relations to direct sensory and perceptual originals.

Evidences of the subjective character of ideas.

The distinctly subjective character of ideas is strikingly evidenced by the individual differences noticed above. Every person has his own idea when he turns away from an object. So true is this, that courts of law often find it very difficult to determine from the accounts offered by perfectly honest observers with different personal interests and points of view, the exact relations which existed in the objective world. Galton found certain individuals who have curious personal methods of organizing experiences. Thus, he found that there are some who arrange the numerals in definite visual systems. Whenever they make the transition from ten to fifteen, for example, they pass in their own subjectively constructed series from one visualized point in the image to another point corresponding to the second number. Figure 52 exhibits several of these number forms, as Galton called them. These are very excellent illustrations of individual modes of organizing experience, for they show that certain persons make as concrete as possible the very abstract fact of number sequence. When a person who does not have a number form passes from one number to another, he must have some kind of an idea of change, but ordinarily he does not translate it into spatial sequence. Other unusual forms of imagery were also reported by Galton. Some persons think of the letters which they perceive when they read as having certain colors. Some think of the months of the year as ar-

ranged in a definite circle or ellipse, and some see the parts of such a figure variously colored.

The emphasis in ideas depends on subjective considerations.

The examination of one's own ideas confirms the statement that they are distinctly subjective in character. One can control the emphasis in memory images much more fully than in percepts. Thus, if the interest of the moment is in the form of the object recalled, the sensory qualities can be almost entirely ignored. This makes it possible for individuals who have ideas to use them even in the presence of objects and to make an analysis of perceptual experiences by superimposing ideas on the percepts. Thus, if one who has developed ideas of space looks at a cube and thinks about its form, he may emphasize in the percept, which is full of concrete factors, the special characteristic of form which is almost entirely devoid of concrete content. The emphasis of form is an ideational emphasis imposed upon the perceptual impression.

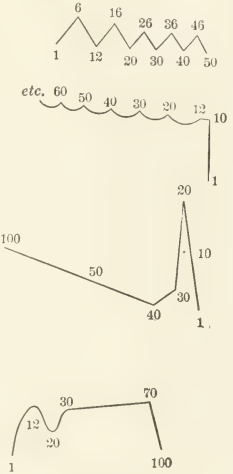

FIG. 52. Number forms copied from Galton. The special significance attached to the figure *12* in certain of these forms may be related to the early training of the individual in connection with the numbers on the clock face. The special position given to *10, 20, 30,* etc., hardly needs comment.

Ideal space is easily traversed.

Another illustration of the subjective character of an idea is to be found in the fact that one can pass instantly, in surveying his memory image, over great ranges of time and space. The idea is not spread out in the same way as is the percept. There is, to be sure, in the idea a

recognition of the spatial character of the image, but space in the idea is not so important in determining the mode of examination.

Ideas related to physiological processes in the association areas of the cerebrum.

The indirect, subjective character of ideas is related to what we know of the physiological conditions of ideas. The physiological conditions of ideas are undoubtedly provided for in the coördinating processes in the association areas of the cerebrum. In the lower animals where the association areas are small or lacking, there is little evidence of ideas. In these animals sensory processes pass to motor discharge with greater directness than in man. In like manner, the infant seems to be wholly absorbed in percepts. This is related to the fact that the tracts in the association areas are the latest to develop, the process of development being, as noted in an earlier chapter, distinctly traceable for a long period after birth.

Animal behavior direct and perceptual, human behavior indirect and ideational.

The significance of the evolution of the association areas can be seen by contrasting the modes of human behavior with the modes of behavior exhibited lower in the scale of life. If an animal is aroused to anger by some stimulation, it responds by directly attacking the source of the stimulation. If an animal is pleased by some form of agreeable excitation, it makes clear its pleasure in an immediate reaction. There is in animal life very little delay or indirection in response. This type of organization explains the fact that only those sensory impressions are taken up in the mental lives of animals which are of direct importance in guiding immediate behavior. When we contrast all this with human life, we are impressed by the fact that man's activities are most of them indirect. This appears, for example, when we consider that man's activities are many of them reactions of articulation. Articulation is not a direct form of bodily attack upon an enemy, or a direct bodily movement of seizing food, or of flight in fear. Articulation is an indirect form of activity and it is very significant that it has developed to a degree which makes it a matter of cardinal importance in discussing human life. A second example of the indirect type of activity which man has cultivated is seen in

the fact that he employs tools, rather than parts of his body, in his conquest of the world. The use of a tool to attain certain ends calls for an entirely new system of activities of manipulation and for a most elaborate nervous organization. Thus, the animal which strikes at its prey with its claws and has no experience of striking other than that which can be developed through the use of its own organs, will face any situation in the world with a very much more immediate attitude of direct contact than does the man who has learned to attack his prey at a distance through the use of arrows or other weapons. The manipulation of a weapon with the ulterior purpose of causing the weapon to do the work which is desired, involves a double adjustment and a double attitude toward the factors of experience. There are the direct adjustment and attitude which apply to the weapon or tool itself, and the indirect attitude toward the object which is to be acted upon by the tool; and, finally, in order that these two may be properly related, there must be some attention to the relation between the tool and the more remote object.

Ideas late products of mental development.

There is an unmistakable relation between these indirect forms of activity and the development of the typical forms of ideational consciousness. Language is so important a topic that it will be considered at length in the next chapter. If one studies the historical development of the use of tools, he will find that the most primitive peoples use only a very few simple devices, and these simple devices are hardly more than imitations of the patterns found in their own organs. The progress of civilization was in this period very slow. As soon as mental development reached the level where man could give attention to broader relations through the development of ideas, there came a radical and rapid change in the character of human culture. It is difficult for a civilized individual to realize that ideas are the latest products of mental development and that they are very uncommon at levels of life below that at which man lives. The moment we begin to make an introspective study of consciousness, we find that we are dealing with ideas,

and these seem, from the point of view of mature experience, to be the most commonplace phases of mental life. Indeed, it is difficult to offer a good illustration which will show clearly the difference between direct perception and indirect thought processes, for so complete is the development of the indirect mode of thought in developed human beings that the moment one begins to consider an experience for purposes of scientific illustration, he naturally begins to turn over in his experience a series of ideas rather than direct percepts. Man has gone so far in this direction that he takes an outsider's view of himself. He not only uses his arms, but he thinks about them as if they were tools. In order to get an illustration of direct forms of experience we must, therefore, assume for the moment the attitude of a person wholly absorbed in the direct application of himself to a situation. Suppose that one is trying to grasp an object just beyond the limit of his ability to reach. His attitude in the midst of that situation is very direct. Space is not a separate and distinct phase of experience. The whole attitude of mind is one of direct adaptation. The individual is so absorbed in meeting the situation that he does not think about it; he is not likely to be able to describe, after the experience is over, the efforts he made, because the whole process is in the sphere of direct experience to which ideational forms of thought and indirect verbal descriptions are not readily applied. The moment the man stops reaching and begins to consider devices by which he may help himself, the whole character of experience changes. Space, and the object, and the man himself are now contents of thought and their relations are subjects of consideration. This is the sphere of ideational experience which lends itself readily to description.

Illustration of direct and indirect forms of consciousness.

The ability to think indirectly is an achievement which has no equal in importance in the evolution of the animal kingdom. The mode of life in an animal endowed with this power can never again be characterized as direct. Language, as perhaps the most characteristic mark of this new power of indirect thought,

Indirect adaptation the highest form.

takes a place among motor activities which is more important than that of any of the grosser and more direct forms of activity.

Ideas are highly developed processes based on memory images.

Again it is to be pointed out that ideas thus broadly considered are not forms of memory, but rather unique types of mental organization made possible by the presence in experience of indirect factors easily subject to reorganization. The elaborateness of the organization is the chief fact, not the content used in this organization. When two persons think of a number relation, for example, it is not important that both of them should have the same images in consciousness, but it is all-important that they should treat these images in the same way. They should have the same type of transition from less to greater; they should both agree in taking equal steps when they pass from ten to twelve and from twenty to twenty-two. In short, the mode of organization should be the same in any given system of ideas, whatever the content. The important fact in an idea is thus the relation into which its contents enter. Thus idea is the function of memory factors in much the same sense that perception is the function of sensations. Our further study will take up in detail the various types of organization of the indirect or ideational forms of consciousness.

CHAPTER X

LANGUAGE

Theory that language is a special creation.

THE question of the origin of language is a question which has been much discussed and variously answered from the earliest times. Language is so distinctively a human function that it has often been regarded as a special endowment of man, given to him by special creation.

The special creation theory gives way to naturalistic explanations.

The special creation theory of the origin of language ignores, however, certain facts which are too obvious to be set aside. It ignores the fact that animals have the ability to make certain vocal sounds which they utilize for purposes of communication with each other. We cannot explain how it is that animals have modes of expression so closely related to human language without, at the same time, recognizing the natural origin of language itself. Furthermore, the processes of human expression are constantly undergoing changes and developments which are so natural and so definite in their character that it seems improbable that language ever failed to exhibit development. If the principles under which language as we know it is developing, can be ascertained, it is reasonable to project these laws back of the historical period and to assume that the beginnings of language were also under the regular laws of development. The creation theory has, therefore, gradually given way to various theories which attempt to give a naturalistic explanation of language.

The imitation theory only a partial explanation.

It has sometimes been held that language originated from the tendency to imitate sounds. This theory, while it would explain certain of the special forms of words, cannot give any adequate account of the way in which an imitating individual develops the

power to use his imitations for purposes of speech. There are a number of different animals that are capable of a wide range of imitation, but they have never developed a language, as has man. This is clear evidence that the essence of language is not to be found in imitation, but rather in the use to which the imitative power is put.

The interjection theory also partial.

It has also been suggested that language developed out of the interjections which man naturally used in his most primitive stage of development. If he was astonished by any sudden stimulation, he naturally gave forth ejaculations in response to the sudden excitation. These ejaculations, it is said, came gradually to have the character of the situations to which they belonged and ultimately to serve the purposes of communication. Here again, the objection to the theory is not that it seems improbable that man began with simple forms of expression, but the theory does not explain how these simple forms of expression acquired a meaning and importance which they did not have at the beginning. What is needed, rather than a formal description of the first expressions used by primitive man, is a consistent psychological explanation of how the ejaculations came to have significance for mental life and to serve as the vehicles for elaborate thought processes.

Language has its roots in natural emotional expressions and their imitation.

The psychological explanation of language must begin with a general reference to the statements made in earlier chapters. Every sensory stimulation arouses some form of bodily activity. The muscles of the organs of circulation and the muscles of the limbs, as well as other internal and external muscles, are constantly engaged in making responses to external stimuli. Among the muscles of the body which with the others are involved in expressive activities are the muscles which control the organs of respiration. There can be no stimulation of any kind which does not affect more or less the character of the movements of inspiration and expiration. In making these general statements, we find no necessity for distinguishing between the animals and man; so far as the general

facts of relation between sensations and expression are concerned, they have like characteristics. That an air-breathing animal should produce sounds through irregularities in its respiratory movements when it is excited by an external stimulus, especially if that stimulus is violent, is quite as natural as that its hair should rise when it is afraid or that its muscles should tremble when it is aroused to anger or to flight.

Activity becomes a means of communication, first through imitation.

The important step in the development of language is the acquirement of the ability to use the movements of the vocal cords for purposes other than those of individual emotional expression. The acquirement of this ability is a matter of long evolution and depends in its first stages upon imitation. The function of imitation as a means of communication between animals appears as soon as animals begin to live in packs or herds or other social groups.

The imitative communications of animals and man are of great variety.

So far as communication through imitation is concerned, there is no reason why attention should be confined exclusively to the forms of activity which result in sounds. All animals imitate the activities of other members of their species on a very large scale. The stampede of a herd of cattle is an excellent illustration of the importance of the tendency toward imitation. The frightened animal which starts the stampede does not consciously purpose to communicate its fright to the other members of the herd; it is performing a natural act of its individual life. Incidentally, it affects all those about it by arousing in them a violent form of imitative activity. The stampeding herd may have no consciousness whatever of the original cause of fear in one of its members; the real cause of the stampede and of the resulting excitement in the herd is the example of the one frightened animal. Thus we see that the activity of an animal takes on, because of the reaction of its social environment, a significance which the original act never could have had unless it had been imitated.

What is true of activity in general is true of activities which result in sounds. The sound produced by the activities of the vocal cords can impress itself readily

upon the ears of some other animal, more readily by far than the visual impression of trembling or of general muscular tension. If, now, the animal which hears the sound has itself produced this sound or one closely resembling it in quality and intensity, there will be a natural tendency for the sound stimulation to arouse in the second animal a sympathetic response. Witness the tendency of all of the dogs in a community to bark together or of all the roosters to begin crowing together when one gives the signal. The result of imitating the sound will be to throw the imitating animal into an emotional state very similar to that of the animal which first made the noise. This result will be more likely to follow if the two animals are closely related in their organization and types of activity. There will be relatively less tendency to sympathize with an animal of entirely different organization and habits, for the activity aroused through imitation in the listening animal will not agree in character with the activity of the animal which sets the example. Thus, one can judge from his own experience that there is very little possibility of arousing in a human being the exact state which appears in dogs or cats through imitation of the sounds which they produce. In general, imitation of sound is valuable as a means of arousing sympathy only between animals sufficiently related to each other to have similar modes of producing sound.

The value of sounds as means of social communication.

Given the similarity of organization which makes imitated sounds significant, we have a type of communication provided, which is widely utilized in the animal world. The food calls and the danger signals of birds are significant to other members of the flock. Such calls have definite natural relations to the organized responses of all members of the species. It is to be noted that these calls do not constitute a language in the sense in which human sounds constitute a language, for the bird calls are incapable of conveying definite ideas, such as ideas of the kind of food or the particular kind of danger discovered by the animal which makes the sound. The sounds serve merely to arouse certain

Animal language communicates only attitudes.

attitudes. An animal can fly away and can induce in its fellows a like tendency to fear and flight, by means of cries which in the history of each member of the flock, have been associated with fear, but the animal can go no further in its communications than to express its own natural tendencies and corresponding attitudes.

The first stages of human articulation are like animal cries.

There are stages of human infancy which are closely related to the stages of animal life thus far described. The human infant does not at first make sounds as the result of any conscious desire to communicate its feelings to those about it, much less does it use its sounds for verbal discussion of the details of its conscious experiences. The infant makes noises exactly as it swings its arms and legs, because the muscular contractions which produce these noises are instinctive motor expressions related through heredity to the stimuli which arouse them. Later there appears a strong tendency to imitate others of its own kind, and this imitation may serve to put the infant in some contact with its social environment, and give it a medium of communication comparable in character to that which we find in animals. This is not language, however, for imitation alone is not enough to develop language. Further processes must take place before the full development is effected.

Articulations are selected from the sum of possible activities.

While imitation applies to many different forms of activity, such as those of the limbs or face, a moment's consideration will make it clear that the activities which produce sounds have a number of unique advantages as vehicles of imitative communication. The ability to produce sounds depends largely upon the animal itself and very little upon external conditions. Contrast sound with visual impressions. Visual impressions are cut off in the dark; they are cut off by intervening objects, and by a turning of the head of the observer. Sounds travel wherever there is air; they are as easy to produce in the darkness as in daylight; they can easily be varied in intensity. For these reasons they come to be the chief means of social communication, even among the animals. The result is

that the vocal cords and the ability to discriminate sounds are highly developed long before the development of language proper.

Sounds became language in the proper sense through association with ideas.

The advance which human language makes beyond animal communication consists in the fact that human language relates sounds to ideas as well as to emotional attitudes. How man came to take this step cannot be understood apart from the general fact that in every respect human mental development was and is of the ideational, rather than of the direct perceptual type.

The ability to use language and to deal with ideas developed together.

The inquiry is involved at this point in a perplexing circle. Human mental processes as we know them are intimately related to language. Even when we think about our own most direct experiences, we use words. When we enlarge our associations, we usually do so with the aid of words. Yet these words do not seem at all explicable except when we assume complex ideational processes as the necessary conditions for their development and interpretation. Did human mental advance result from the development of language, or did language result from the development of associational processes? The only answer to this question is to say that language and ideational processes developed together and are necessary to each other. So long as animals were absorbed in direct responses to the demands of their environment, their mental complexes were of a direct, primitive type, and stimulations issued into direct motor channels with relatively little possibility of ideational organization. As soon as a type of response developed which was indirect, there was a complete change in the general mode of bodily and conscious organization. Attention was turned to many objects in the environment which had at an earlier stage little or no value for individual life, because there was no appropriate mode of direct activity which could be applied to them. Speech is a universal mode of expressive reaction and makes it possible for one who possesses it to react in discriminating fashion upon anything. Thus, if one has different names for two objects which resemble each other closely, he will be aided in discriminating them through the use of the different

verbal reactions to them. Speech is, accordingly, both a product of ideation and an aid to its development.

Muscular activities involved in articulation are indirect.

Nothing can emphasize the fact that language is related to indirect ideational processes more than the selection of the vocal cords for the execution of speech reactions. The vocal cords are, more than any other active organs, wholly useless for direct adaptations. Those natural expressive gestures which were common among primitive men very soon gave way as means of communication after the development of movements of articulation. The reason for this is clear in view of the fact that the hands and grosser muscles are constantly in use in the direct practical activities of life. When two individuals wish to communicate with each other, it is often extremely inconvenient to suspend all other activity, to lay down what one may be carrying, to come where one may be clearly seen, for the purpose of holding a parley. The vocal cords, on the other hand, are not required for the practical purposes of life. They are easily disconnected in their action from the general mass of the muscles and, therefore, very naturally became the organs for a system of responses indirect in character and value as compared with the practical responses of the other muscles.

Language a development of natural tendencies.

When human language is thus viewed as a selection of the activities of the vocal cords from the sum total of the expressive activities, and as a series of associations of articulations and sounds with ideational processes, it becomes evident that the studies of language are at once placed upon a naturalistic foundation. The various forms of articulation may be studied exactly as other forms of reaction are studied. The habits of articulation in an individual or a race are recognized as matters of motor coördination. The special forms of words are matters of accidental associations and may depend on the greatest variety of circumstances. Thus, it is equally possible for a word to originate in the imitation of a sound produced by an animal or by another human being, or in an ejaculation which is a purely personal reaction. The source of the sound is of no great importance; the association into which the

sound is taken up is what renders it significant. The essential conclusion for psychology is that language is a system of indirect social forms of reaction, associated with complex ideational processes.

Writing a type of expression which shows the nature of languages.

The transition from relatively direct perceptual processes to highly organized associational processes, which is characteristic of all language, is clearly shown in the history of written forms of language. Furthermore, the record of the development of writing is sufficiently accessible to make it a very convenient means of illustrating the development of language.

Writing at first direct in form.

The earliest stages of writing were those in which pictographic forms were used; that is, a direct picture was drawn upon the writing surface, reproducing as nearly as possible the kind of impression made upon the observer by the object itself. To be sure, the drawing used to represent the object was not an exact reproduction or full copy of the object, but it was a fairly direct image. The visual memory image was thus aroused by a direct perceptual appeal to the eye. Any one could read a document written in this pictographic form, if he had ever seen the objects to which the pictures referred. There was no special relation between the pictures or visual forms at this stage of development and the sounds used in articulate language. Concrete examples of such writing are seen in early monuments, where the moon is represented by the crescent, a king by the drawing of a man wearing a crown.

Images can be reduced to lowest terms as powers of reader increase.

The next stage of development in writing began when the pictographic forms were reduced in complexity to the simplest possible lines. The reduction of the picture to a few sketchy lines depended upon the growing ability of the reader to contribute the necessary interpretation. All that was needed in the figure was something which would suggest the full picture to the mind. Indeed, it is probably true that the full picture was not needed, even in the reader's consciousness. As we have seen in our earlier discussion of memory, memory images are usually much simplified reproductions of the perceptual facts. In writing we have a concrete expression of this tendency

of memory to lose its full reproductive form, and to become reduced to the point of the most meager contents for conscious thought. The simplification of the written forms is attained very early, and is seen even in the figures which are used by savage tribes. Thus, to represent the number of an enemy's army, it is not necessary to draw full figures of the forms of the enemy; it is enough if single straight lines are drawn with some brief indication, perhaps at the beginning of the series of lines, to show that these stand each for an individual enemy. This simplification of the drawing leaves the written symbol with very much larger possibilities of entering into new relations in the mind of the reader. Instead, now, of being a specific drawing related to a specific object, it invites by its simple character a number of different interpretations. A straight line, for example, can represent, not only the number of an enemy's army, but it can represent also the number of sheep in a flock, or the number of tents in a village, or anything else which is capable of enumeration. The use of a straight line for these various purposes stimulates new mental developments. This is shown by the fact that the development of the idea of the number relation, as distinguished from the mass of possible relations in which an object may stand, is greatly facilitated by this general written symbol for numbers. The intimate relation between the development of ideas on the one hand and the development of language on the other is here very strikingly illustrated. The drawing becomes more useful because it is associated with more elaborate ideas, while the ideas develop because they find in the drawing a definite content which helps to mark and give separate character to the idea.

Written symbols and their relation to sounds.

As soon as the drawing began to lose its significance as a direct perceptual reproduction of the object and took on new and broader meanings through the associations which attached to it, the written form became a symbol, rather than a direct appeal to visual memory. As a symbol it stood for something which, in itself, it was not. The way was thus opened for the written symbol to enter into relation with oral speech, which

is also a form of symbolism. Articulate sounds are simplified forms of experience capable through association with ideas of expressing meanings not directly related to the sounds themselves. When the written symbol began to be related to the sound symbol, there was at first a loose and irregular relation between them. The Egyptians seem to have established such relations to some extent. They wrote at times with pictures standing for sounds as we now write in rebus puzzles. In such puzzles the picture of an object is intended to call up in the mind of the reader, not the special group of ideas appropriate to the object represented in the picture, but rather the sound which serves as the name of this object. When the sound is once suggested to the reader, he is supposed to attend to that and to connect with it certain other associations appropriate to the sound. To take a modern illustration, we may, for example, use the picture of the eye to stand for the first personal pronoun. The relationship between the picture and the idea for which it is used is in this case through the sound of the name of the object depicted. That the early alphabets are of this type of rebus pictures appears in their names. The first three letters of the Hebrew alphabet, for example, are named respectively, aleph which means ox, beth which means house, and gimmel which means camel.

The complete alphabet as an achievement of conscious organization.

The complete development of a sound alphabet from this type of rebus writing required, doubtless, much experimentation on the part of the nations which succeeded in establishing the association. The Phœnicians have generally been credited with the invention of the forms and relations which we now use. Their contribution to civilization cannot be overestimated. It consisted, not in the presentation of new material or content to conscious experience, but rather in the bringing together by association of groups of contents which, in their new relation, transformed the whole process of thought and expression. They associated visual and auditory content and gave to the visual factors a meaning through association which was of

such unique importance as to justify us in describing the association as a new invention.

Written symbols may fail to take on associations with sounds.

There are certain systems of writing which indicate that the type of relationship which we use is not the only possible type of relationship. The Chinese, for example, have continued to use simple symbols which are related to complex sounds, not to elementary sounds, as are our own letters. In Chinese writing, the various symbols, though much corrupted in form, stand each for an object. It is true that the forms of Chinese writing have long since lost their direct relationship to the pictures in which they originated. The present forms are simplified and symbolical. So free has the symbolism become, that the form has been arbitrarily modified to make it possible for the writer to use freely the crude tools with which the Chinaman does his writing. These practical considerations could not have become operative, if the direct pictographic character of the symbols had not long since given place to a symbolical character which renders the figure important, not because of what it shows in itself, but rather because of what it suggests to the mind of the reader. The relation of the symbol to elementary sounds has, however, never been established. This lack of association with elementary sounds keeps the Chinese writing at a level much lower and nearer to primitive pictographic forms than is our writing.

Symbolism as an indirect form of expression.

Whether we have a highly elaborated symbolical system, such as that which appears in Chinese writing, or a form of writing which is related to sound, the chief fact regarding writing, as regarding all language, is that it depends for its value very much more upon the ideational relations into which the symbols are brought in the individual's mind than upon the impressions which they arouse. No clearer illustration could be given of the fact that the experiencing individual builds up a system of associations which are essentially indirect, rather than sensory or perceptual.

The ideational associations which appear in developed language could never have reached the elaborate form which they have at present, if there had not been social

coöperation. The tendency of the individual when left to himself is to drop back into the direct adjustments which are appropriate to his own life. He might possibly develop articulation to a certain extent for his own sake, but the chief impulse to the development of language comes through intercourse with others. As we have seen, the development of the simplest forms of communication, as in animals, is a matter of social imitation. Writing is also an outgrowth of social relations. It is extremely doubtful whether even the child of civilized parents would ever have any sufficient motive for the development of writing, if it were not for the social encouragement which he receives.

Social motives essential to the development of language.

Furthermore, we depend upon our social relations, not merely for the incentives to the development of language, but also for the particular forms of association which oral and written language shall take. It is much more convenient for a child born into a civilized community to adapt himself to the complex symbolism which he finds in the possession of his elders than to develop anything of the sort for himself. It is true that tendencies exist early in life toward the development of individual forms of expression. A child frequently uses a certain sound in a connection which cannot be explained by reference to social usage. It may be a purely individual combination, or a crude effort to adopt something which has been suggested by the environment. This tendency to give sounds a meaning might prove sufficient to work out a kind of language, even if the individual were entirely isolated from his fellows; but the natural tendencies are very early superseded by the stronger tendencies of social imitation, and in the end the social system completely dominates individual development.

The social system dictates the form of words.

In adopting the forms of expression used by those about us, we are led to take up certain general social forms of thought which ultimately control the whole mental life. The effect of this social influence is so far-reaching that it is quite proper to say that an individual is, in a very large measure, the creation of his social relations, at least in the higher phases of his

Social usage determines many of the details of thought.

mental life. The fundamental forms of direct activity, which constitute the personal habits by which we have succeeded in adapting ourselves to the demands of the physical world, are to a certain extent unsocial. They are, to be sure, alike in different individuals because they have grown up, as was shown in our earlier discussion, under the demands of a common physical environment. Our forms of space perception, for example, are not the creations of our own individual caprice, but rather the arrangement which we have given our sensory experiences in our effort to fit ourselves to a world which dictates these space relations to us. The community of social ideas expressed in language is of a different type. Even the direct, relatively unsocial forms of perception are influenced by these higher social forms of thought. If, for example, there is no word in a certain social environment for long spatial distances except a word which refers to a certain number of days' journeys, it is not likely that the individual will feel any tendency to discriminate fifteen miles from seventeen. His attitude in this matter will be determined by the attitude of his social environment, and he will neglect in his thought, as do those about him, the finer details of distance. Similarly, if there are no names for certain forms of property rights, it is not likely that the individual will, of his own initiative, recognize these forms of right as belonging to others.

Social ideas develop and dominate individual life.

The history of thought has been, in large measure, the history of the development of certain social ideas which could be marked with definite names and made subjects of thought, because they were so marked. Consider for a moment the difficulties which would be experienced in conducting any train of thought with regard to the forces of physical nature, if there were no names for the different forces and no fully developed definitions to give each name clearly recognized character. If it is true in a general way that general tendencies of thought have been dependent upon the development of words to express ideas, it is still more true in the case of the individual that his mental tendencies are very largely determined by the forms

of social thought expressed in words. A child who has had his attention called to certain colors and who is, at the same time, given a name for these colors, is more likely to identify them in later experience than if no name had been given. The name serves as an incentive to the concentration of attention upon a particular phase of experience which would otherwise be lost in the general mass of sensations. Without the word, the possibility of dwelling upon the single phase of experience in thought would be small. This is the reason why the retention of facts in memory is so closely related to the naming of objects. Some experimental evidence can be adduced to show that names are of great importance in this respect. If one is confronted with a large number of pieces of gray paper ranging from black to white, and is asked to discriminate as many of these different grays as he is able to recognize with certainty, it will be found that he can distinguish ordinarily about five classes of gray shades. He can distinguish the very dark from those which are medium dark, the very light from those that are medium light, and he can place between the dark and the light grays a middle shade which he is not disposed to classify as either light or dark. Beyond this fivefold discrimination, he will find that he is very uncertain. If, now, after making this test under ordinary conditions, the individual is allowed to examine the various shades of gray and to adopt a series of names or numbers for them, it will be found that he can notably increase the range and certainty of his discrimination. The names furnish, as stated above, definite means of concentrating attention upon slight differences which existed from the first, but were not noted in experience. Furthermore, when these slight differences have been discriminated and marked by the attachment to them of definite names, they become permanent additions to the individual's equipment and can be retained more easily than they could be as mere unnamed sensation qualities.

Experimental evidence of importance of words.

One of the best illustrations of the significance for mental life of the creation of a terminology is found in

Number terminology grew up with the increase in possessions.

the ease with which a developed individual uses numbers. In general, it may be said that primitive languages have only a very meager number terminology. Savage tribes have frequently been known to have no number terminology reaching above ten, and in some cases tribes have been reported with a number terminology not reaching beyond three. There are certain forms of direct perceptual experience which can be utilized up to a certain point instead of the developed number system which we now have. If a herdsman has a herd of cattle for a period long enough to become acquainted with its individual members, he can recognize the size of the herd by recalling the individuals which make it up. If one has material possessions which can be heaped together, he will come to estimate his wealth directly through the general impression made upon him by collecting all of his wealth at a single point. As soon as the direct recollection of each individual possession came, in the development of human wealth, to be too cumbersome a form of representation, and the collective image became too vague to be relied upon, man naturally endeavored to devise a method of recording his property and retaining it in consciousness in some simplified form. Instead of trying to remember every one of his possessions, he adopted some system of tally. At first he began counting off on his fingers each different article which he wished later to be able to recognize, or he adopted in some cases one of the more elaborate methods found among savages who use pebbles or shells. The Latin root which appears in our word "calculate" and all related words is the word for pebble, and indicates that the early forms of enumeration among the Romans consisted in the use of pebbles.

Symbols for groups of tallies.

As soon as the system of enumeration became complex, there naturally arose the necessity for grouping the tallies so that they could be easily surveyed. The method of grouping the tally marks in a system convenient for recognition is suggested by the five fingers on the hand, and this is often adopted, even by savage peoples. A clear indication that this grouping appeared in the natural tally systems can be seen in the

symbols used by the Romans to indicate numbers, for in this system the number five and the number ten are crucial points in the notation, and show the adoption of a new group symbol to include many individual symbols in a more compact form.

Number names develop as the system grows complex.

As the number system was worked out into a system of major and minor groups, there was a tendency to develop a system of articulation directly related to the tally system. Number of the primitive tally form probably developed just as did writing, without reference to speech. The creation of words which should express number was slow, as indicated by reference to savage language, because in this case the symbolical system needed to develop to a high degree before the demand for corresponding articulation was felt. As soon as the demand for articulation became sufficiently pressing, the words appeared, and they show distinctly in their character the tendency toward groups. Further than this, the names for successive tallies came to be the means, not only of referring to individual marks, but also of referring to the serial arrangement of these marks. Thus, the names one, two, three, etc., are not significant merely as names of tally marks; they have also each its special significance as the name of a special position in the total series.

The development of arithmetic depends on an appropriate system of numerals.

The advantage to the child who finds a complete number terminology developed is very great. The more perfect this terminology for purposes of expressing quantitative relations, the more complete and rapid will be his initiation into the forms of thought which the terminology expresses. The historical illustration of this fact is to be found in the acceptance by European nations of a system of notation which was imported from the East in the Renaissance period. The written number symbols which had been used by the Romans were crude, and rendered any forms of arithmetical manipulation extremely difficult. The Arabic system was so much more complete and economical that it immediately took the place of the older and cruder symbolism. How long it would take an individual child to acquire independently anything like the

mathematical ability which, with the aid of his social environment, he acquires through the adoption of the developed Arabic number system, can hardly be imagined. Certain it is that his forms of thought are now dominated by the social system into which he is born, and this system was in turn borrowed *in toto* from non-European nations.

The social world a unified whole through common forms of thought.

There is in this acceptance of the social system, not only an economy which operates to the advantage of the individual, but there is the additional fact that the individual becomes thereby a part of the social whole in a fashion which is significant for society as well as for himself. We are bound together as intelligent beings by the common systems of tradition and language to a degree which makes us no longer centers of merely individual adaptation, but rather parts of a general organization which has a certain unity and exercises a dominating influence over many individuals. This social unity perpetuates in this way customs and practices so that we have, in addition to the bodily structures which we inherit, a social heredity which guides us in the activities of personal life. Language is the chief medium for this social heredity.

Changes in words signify changes both in individual thought and social relations.

It is in connection with the development of social institutions that we find the most radical changes in human language. If an individual comes upon a new idea and coins a new word for its expression, the new word gains standing and comes to be a part of the permanent language of the community only when others feel the same necessity as the inventor of the word for this new means of expression. When, therefore, we have a long history of variations in any word, we may depend upon it that there has been a corresponding series of social as well as of individual experiences related to the word. The detailed history of words is, therefore, a detailed history of individual mental attitudes toward the world, and at the same time a detailed history of the social relations in which individuals have joined.

It will not be in place in this connection to enter into any elaborate linguistic studies, but one illustra-

An illustration of the significance of changes in words.

tion may be used to indicate something of the character of the psychological and social study which grows out of the history of words. In his *English Past and Present,* Trench gives an account of the development of the word "gossip." This word was originally used at baptismal ceremonies and referred to the sponsor who stood for the child in a way analogous to that in which to-day the god-parent stands as sponsor for the child. The first three letters of the word "gossip" are derived directly from the word "God," and the second part of the word, namely, "sip," is a modification of the word "sib," which is even now used in Scotland to indicate a relative. When the social institution of baptism was a matter of larger community significance than it is to-day, the word was needed to express the relationship of the individuals involved in the ceremony; but being a general form of expression rather than an image of a particular individual, it came easily to refer to other phases of social contact than that which was primarily thought of in connection with the baptismal ceremony itself. The worthy sponsors of the child unquestionably indulged, even in the early days of the ceremony, in certain exchanges of information with regard to other members of the community, and this social function which the individual served was very readily connected with the word coined to refer primarily to the religious function. As the religious ceremony came to be less and less elaborate, and there was a decreasing demand for reference to the religious function, the word gradually drifted over to the second phase of meaning. It is probably true that the aberration of form, which appears in softening the *d* in God to an *s*, made this transfer of meaning easier. Indeed, as we have seen at various points in our discussions, words become true symbols only because they are simplified so as to take on easily new types of relation. Thus, the word "gossip" ultimately lost its original meaning and came to signify something which it signified only very vaguely to the minds of those who first used it. Furthermore, it is very clear that this transfer of meaning is directly related to the development of the

social institution with which the word was connected. The mental attitude of the individual who uses the word to-day, and the social character of the institution, are both entirely different from the attitude and institution of earlier times.

Words carry thought very far from immediate experience.

Other illustrations of the developments which take place in language can be found in the introduction of new words with new inventions and new discoveries in science. Once the habit of using words is thoroughly established in a community or individual, it furnishes an easy method of marking any experience which it is desired to consider apart from the general setting in which that experience appears. If to-day a civilized individual wishes to think of a certain relation and consider its bearings upon all of the factors which enter into the relation, he will devise some word or phrase by which to mark the relation and hold it clearly before his thought while he considers all of the possible bearings of this relation. There comes to be thus a system of experiences which we are justified in describing as constructed in consciousness for the purpose of guiding attention; these constructs have, as contrasted with ordinary mental images, very little content. Indeed, the reduction of the content of thought to the lowest possible minimum is the tendency of all mental evolution. The child has undoubtedly a fuller and more vivid imagery than the adult. The adult finds as he learns to use words fluently that the imagery which at first was necessary to explain them, falls away. The result is that great ranges of thought can be much condensed. In the discussion of habits it was shown that as experience becomes more completely organized into habits, the memory content and even the sensory contents receive less attention. An organized attitude is substituted for a complex of content factors. In somewhat analogous manner, words may be regarded as means of epitomizing consciousness, while they permit the highest type of ideational elaboration of experience. The widest variety of content factors may be related to words; that is, the use of a word is often cultivated under the guiding influences of concrete content.

After a time the concrete memory images attached to the word fade out and leave the word as a substitute, as a minimum content to which an elaborately organized meaning may attach.

Images do not appear as important phases of verbal ideas.

When, therefore, we ask what it is that a person thinks of in his use of a word, we shall certainly go astray if we attempt to answer that the word calls up all of the concrete experiences with which it has been connected and with which it may be connected. For example, take such a word as "animal," and let the reader ask himself what presented itself in consciousness when he first observed this group of letters on the page before him. It would be still better if, instead of choosing some word thrown into the text as an isolated illustration, we should ask the reader to give an account of the mental experiences through which he passed when he observed one of the words that came in the course of the general discussion. For example, what was called up a moment ago when the eye passed the very definite word "text"? The answer to these questions with regard to the content of consciousness at the moment of recognition of words will certainly not be that the mind is filled with trains of concrete images.

The characteristic phase of a verbal idea is the attitude which it arouses or the turn which it gives to thought.

The consciousness of a word has sometimes been described as a feeling or an attitude, and such a description as this unquestionably comes nearer to the truth than does the explanation of meaning through images, which has sometimes appeared in psychological discussions of this matter. A general term such as "animal" or "text" turns the thought of the reader in one direction or the other without filling the mind with definite contents. The content of experience arises rather from the total phrase or sentence; the single word indicates only the direction in which this content is to be sought, or in which it is to be applied in some future stage of mental activity. For example, if I say that all animals are subject to man's dominion, there is much more of attitude in the whole experience than there is content. We look down upon the animals; we feel their inferiority; we recognize ourselves as above them. The attitude of mind experienced is the all-important fact. There

is an experience of personal elation, which may perhaps be worked out into imagery, if one contemplates it long enough. Thus, one may turn the thought into images by thinking of himself for the moment as the representative man looking down upon the animals gathered as he saw them in childhood in some picture of Adam naming the animals. But all this concreteness in one's description of the animals and of himself is recognized as too picturesque to be true to ordinary experience. We can stop and fill out the attitude with appropriate imagery if we like, but we do not ordinarily do so. The truer statement is that the idea comes as a single simple attitude and prepares one to go on from a position of superiority to some appropriate sequent relation. The value of the words lies in the fact that they carry experience forward, furnishing only so much content as is necessary to support thought without overloading experience with all the detail.

Other illustrations of thought relations.

Again, to take another illustration which shows that there may be nicety of shading in our thought relations without much content. If we use such a word as "savage," we are likely to take an attitude of superiority somewhat analogous to that taken toward the animals, but flavored more than the former idea with a concession of equality. Again, if we speak of higher beings, such as angels, we assume an entirely different attitude, without necessarily giving ourselves the trouble to fill in any definite content. Indeed, the content of any thought referring to the higher beings is recognized everywhere as more or less of a makeshift, in that we fill in the unknown with such images as we can borrow from ordinary life, the images being symbols, not true representations.

Concrete words are often connected with incipient bodily adjustments.

All this has been expressed by certain psychologists in the statement that general ideas are in essence nothing but dispositions toward activity. Here we have a formula which is very closely related to the formula which we derived in our discussion of the development of memory processes into percepts. There is, undoubtedly, something of development toward direct motor habits and consequent attitudes in connection

with many concrete words. It is, on the other hand, probably not true that the bodily attitude assumed when we think of the word animal is anything like a complete bodily attitude such as would be assumed in the presence of animals in concrete experience. The mental attitude aroused by the word probably has as its direct physiological parallel a bodily movement which is a much reduced resultant of earlier direct attitudes. It is in its present form merely a faint reverberation, significant, not for direct adaptation, but merely as a step in the development of a general and perhaps very remote form of activity. The present attitude is one of those indirect forms of human adjustment which render the experience of man freer and more ideational than the experience of the animals. The bodily movement in such cases is symbolical and transient, assumed merely for the sake of carrying the individual forward into a more complete state which lies beyond. The matter may be made clear by considering what happens when by means of words one is told that he is to go first to the right until he reaches a certain place, and is then to turn toward the left and go straight ahead. There are clearly certain tendencies toward direct bodily movements aroused by the words "right" and "left" and "straight ahead." These tendencies toward movement, it is true, are not significant as present adaptations to the environment; they are significant merely because they give the thinking individual a certain tendency, which may, indeed, work itself out later in a much more fully developed and concrete form, but is at present a kind of suppressed, incipient form of action. If one has thought out a series of movements toward the right and left, he will have developed within himself a form of behavior which, on the presentation of the appropriate stimulation in the form of the sign-post or building at which he is to turn, will serve as a sufficient preliminary organization to arouse a significant and concrete form of behavior. The preliminary thought attitude and faint bodily expression serve, therefore, in a tentative way to aid subsequent direct adaptations.

Abstract words not explicable by bodily reactions.

If, now, we choose as our illustration, not words of direction, but abstract phrases, such as the phrases by which men are exhorted to patriotism, obviously the emotional stirring which one feels as the result of these exhortations is by no means adequate to explain the true significance of the word "patriotism." A man cannot become truly patriotic by going through the inner stirrings which this word arouses. Indeed, in not a few cases vague emotional responses inhibit rather than promote the development of true interpretations. The trouble with the emotional response lies, not in the fact that it is emotional, but in the impossibility of its expressing the significance which the word must carry. Such an abstract term as that under discussion can be made potent for direct bodily organization only when it is supplied through proper settings with some definite and final purpose of an active kind. The final purpose will then be like the concrete words "left" and "right." The abstract word taken alone is the expression of a relation. If it is treated as a final factor of experience, it will dissipate itself in vague emotional reactions.

Some words are relational rather than concrete.

To take still another illustration, — if in the course of a scientific discussion one is told that a certain problem needs very much to be investigated, the word "problem" will arouse within the individual some kind of a responsive attitude which can be described in a general way as an attitude of hesitation, of turning hither and thither in the search for a solution. But the conscious process will be more than the attitude of hesitation and turning, for it will have a form and significance determined by the whole train of ideas into the midst of which this attitude of hesitation and turning is injected. Thus, if the problem is in geology, the attitude of inquiry will be very different from that which would be assumed if the train of thought related to astronomy. We may, therefore, speak of the attitude aroused by the word "problem" as wholly relational in its character. Another way of expressing the matter is to say that the attitude is in the world of ideas for the time being, rather than in the world of practical

adjustments. We mean by such statements as these, that the attitude is merely a temporary step in the process of ideational organization, it is not an immediate and present form of behavior. It is an indirect and elaborate phase of adaptation; it has value and significance because of the turn which it gives to the ideational process, rather than because of the concrete imagery or bodily activity which attach to the word.

The physiological parallels of relational consciousness.

This gives us a good opportunity to make as sharp and clear a distinction as possible between the forms of nervous organization which are related to direct physiological activity, and those forms of organization which contribute chiefly or only to purely ideational processes. One may say that in complex relational processes stimulations are for a time held in the reorganizing centers and are readjusted on the way to the motor discharge. The more elaborate the forms of organization, the more there will be delay and readjustment in the nervous process. The advantage of readjustment is that opportunity is thus offered for a given simple tendency to be combined with other tendencies before issuing in behavior. Consciousness of the relational or ideational type is thus seen to be related to an intermediate process of reorganization and rearrangement which goes on whenever elaborate readjustments are worked out in the highest associational areas in the cerebrum. Consciousness cannot be understood without recognizing sensory processes or without recognizing the ends of behavior; but the characteristic fact in the higher forms of conscious life is not sensation or motor process, but relational reorganization, which constitutes what we have described as relational ideas.

Contrast between concrete images and abstract ideas.

The indirectness of verbal forms of consciousness and of the related nervous processes involves certain dangers of possible maladjustment. Concrete images and direct forms of experience cannot, because of their limited nature, be turned in very many directions. Verbal ideas, on the other hand, especially if they are abstract, are capable of a great variety of connections because they are so meager and schematic in individual content.

Words should be checked from time to time by concrete images.

In the second place, there is a disadvantage in the use of abstract terms in that two individuals, while they may start with the same general tendency of attention, may, in the course of the use of the words, drift apart, without being as clearly conscious of their divergence from each other as they would be if they dealt constantly with concrete percepts. It is a much more definite method of interchanging ideas to demonstrate the objects themselves, or to demonstrate some concrete representations of the objects, such as pictures or models. If one does not have pictures or models, he naturally tries to correct the errors which are likely to creep in when he is using words, by calling up from time to time as concrete an image in the mind of his listener as it is possible to evoke by the use of words. We all of us feel the relief in any continued discourse when a figure of speech, or an illustration, is used. The figure of speech gives us a fairly concrete image with which to deal. The image in this case may be remote from the immediate subject of thought, it may be related to the present discussion only as a kind of rough analogy, but the presence of some characteristic which illustrates and renders concrete the abstract discussion is a relief in the midst of abstract relational terms, and furnishes the means of correcting possible tendencies toward divergence of thought between the speaker and the listener. An illustration is even more definite in its character, and so long as it calls up in the minds of the speaker and listener the same kind of concrete images, it is a direct corrective of the possible looseness of verbal thought and verbal communication.

Particular images hinder free ranges of thought.

How far one should be picturesque in his language, and how far he should, on the other hand, use terms which are not related to definite mental pictures, is a matter which must be determined by the demands of the particular situation at hand. It would be quite impossible in any generalized science like physics, continually to deal with concrete illustrations. If one speaks, for example, of the general law of gravity, he cannot be dealing with all of the specific cases of gravity known to his experience, nor can he feel him-

self bound to a single illustration. He may come back to the single illustration in order to hold his verbal idea true to the concrete facts, but he should cultivate the ability to get away from the concrete cases into the wider sweep of thought which is covered by the general word.

Ideas or indirect forms of experience characteristic of man.

In concluding this discussion of language, it will be well to reiterate what was said in the earlier chapter on ideas. Human life has taken on, through the development of indirect modes of consciousness and behavior, an aspect which differentiates it altogether from the life of animals. Man lives in a world of ideas. His highest interests lie in the direction of an intelligent reconstruction of his environment. There are percepts and direct forms of reaction in human life as in the life of animals, but the chief aims of human life are expressed in ideas. It is in the realm of thought and reconstructive ideation that individuals aim to excel; it is by their achievements in this direction that peoples give the clearest evidence of their progress. Ideas are the characteristic marks of the human type of life and development. They are broader in their range than percepts or particular images. They are related to the highest processes of organization, namely, the processes of association that take place in the cerebrum which was shown in an earlier chapter to be the characteristic organ of the human body; indeed, the only organ which differentiates man completely from the animals.

CHAPTER XI

IMAGINATION AND THE FORMATION OF CONCEPTS

The range of rearrangement in ideas unlimited.

In the chapter on language, special attention was given to the reduction in content which always takes place as words and ideas are developed and substituted for concrete images. There is another aspect of the ideational process, to which we now turn. As soon as the contents of consciousness appear in the form of indirect factors, they are capable of the greatest variety of new combinations. When a sensation arises in consciousness, there are, at that moment, only a limited number of other sensations to which it can be related. But if this sensation arises in a developed mind, supplied with ideas, there are no limits except the limits of individual experience to the number of factors with which it may be related. If one looks at a circle drawn on a sheet of paper, the perceptual relations of the figure are few and defined; the broader ideational relations which are suggested to the mind of the observer may, on the other hand, be as unlimited as the universe. The rearrangement of experiences in new ideational combinations is consequently an important topic for study.

Tendencies toward rearrangement are present even in simple memory images.

Certain simple forms of reconstruction appear whenever one tries to recall an earlier experience. Seldom, if ever, can one become so absorbed in a memory image as to forget the present factors of experience which give the recalled experience a new setting. Furthermore, associations of similarity and contrast operate at once to make the memory image different from any single scene. For example, if one tries to remember the first time he ever saw a certain building or a certain man, he will realize that his experience is full of a great variety of suggested factors which were not present in the original percept.

When memory images are radically changed in process of recall they are described as imaginations. When the combinations which go on in consciousness are purely capricious, we speak of fanciful imaginations. When, on the other hand, recombinations of mental processes are worked out systematically and coherently, we speak of scientific imagination. When one responds to the objects of his environment with elaborate forms of consideration which make it possible for him to organize his energy and apply it at points where it will be most effective, the mental reconsiderations, which are the means of these more elaborate forms of adaptation, are described by such phrases as practical imagination or mechanical imagination. Imagination.

One of the most primitive forms of imagination is that exhibited by savages when they attribute to inanimate objects the personal characteristics which they find in themselves. The savage never thinks of thunder or of the wind without putting back of it in his imagination some personal agency. This form of constructive thought is the simplest which could originate in a personal consciousness. An emotion of anger is a more direct explanation for a natural catastrophe than is some abstract statement referring to physical force. To modern thought the myths of early peoples seem like the play of the most capricious imagination; to the mind untrained in the forms of critical scientific imagination, nothing could be more natural than a myth. Even the trained mind derives pleasure from the personification of objects, because it is easy to use the factors from personal experience in all manner of combinations. Personifying imagination.

Early man was led by his imaginations to undertake many useless forms of activity. Thus, he attempted to propitiate the personalities which his own mind had put into streams and mountains and trees. There was no direct evidence that his imaginations were not in conformity with the facts, and hence the imaginations went on increasing in complexity until they broke down by their own incoherency. Imaginations may lead to useless activities.

This reference to the fanciful imaginations of primi-

Critical tests of imaginations.

tive man introduces us to the discussion of the more productive forms of imagination in which the mind does not weave together factors of experience capriciously, but under the guidance of conditions which limit the freedom of the constructive process. When imagination is used for purposes of practical construction, or for the later purposes of science, its products must be subjected to critical examination by the individual who develops them. A first principle of criticism of imagination may be described as the principle of empirical test through application. The constructs of imagination may be used to guide activities, and if the activities are not successful, it will obviously be necessary to go over again the combinations which were worked out in consciousness and to revise these combinations with a view to making them more suitable bases for action. We may speak of this form of criticism as the practical or empirical test of imagination. If, for example, a given individual finds that he must get across a certain stream, he is likely, if he has time and the necessary mental development, to consider first in imagination the means by which he can get across. He determines in thought that it would be possible by bringing together certain appliances to make the passage easy. If, on trying the expedients which have suggested themselves in his thought process, he finds that the idea is a good one, his imagination receives the confirmation which comes from practical utility. If, on the other hand, his imagined device breaks down when put to the practical test, he will be led to further considerations of a more elaborate character, in order to correct the deficiencies which have been shown by the practical test to exist in his imagination.

Empirical test is often inapplicable.

There are many ideal constructions which cannot be subjected directly to practical tests. For example, in the course of human history man has constantly been trying to reconstruct in imagination the process of the development of the earth on which he lives. Our modern science of geology is an elaborate effort to reconstruct the history of the earth. Obviously, the ideas

reached by geology cannot be tested by any single practical act. Man has developed, accordingly, a system of criteria by which he tests the validity of his ideal constructions, even when these ideal constructions are not directly intended for the practical uses of life. These theoretical criteria, as we may call them, can be shown to grow out of the nature of experience itself.

The test of coherency of internal organization.

It is demanded by every human consciousness that the elements of any given state shall be capable of some form of harmonious arrangement. We have seen that it is true of perceptual processes that they have unity and arrangement, such that all of the conflicting qualitative factors are provided for in a single experience through the arrangement of the elements of experience in spatial and temporal series. Thus, even in perceptual consciousness, a certain coherency and harmony is required of the elements before they can enter into the percept. Still more when we come to the constructs of imagination is there a demand for harmony of relations among the factors which are presented. If any factor or relation is recognizably incongruous with the system of experiences into which it is introduced, then that system of experience will have to be rearranged until the whole organization is adapted to the reception of the element which was out of harmony with the other elements, or else the incongruous element will have to be rejected. Scientific imagination, when not susceptible to practical tests, is thus nothing more or less than the effort to develop an elaborate system of congruous ideas.

The criterion of coherency is a product of development.

Primitive man does not have this criterion of the harmony of all of the elements as fully developed as does modern science. This is in part due to the limitations of primitive experience, as when a savage believes thunder to be a voice, because he knows little of either the thunder or of the mechanism which produces the voice. It is in part due to a general uncritical attitude, as when in Greek mythology the earth is borne upon the shoulders of Atlas, because attention was not ordinarily concentrated on the necessity of supporting Atlas.

The demand for coherency explains certain scientific ideas.

It cannot be asserted that the criterion of harmony among the elements of imagination is applied with full success even in modern science, but examples can be given without limit of its application. Thus, it is quite impossible for us to think of the earth and the sun as related to each other without, at the same time, conceiving of some form of bridge between the earth and the sun. Science has, therefore, developed the notion of the ether as a continuous substance between the earth and all other points in the universe. The ether is not a factor of direct experience in any form. It is demanded in scientific considerations in order to make the idea of the solar system and of the universe a coherent thinkable idea. Ether may, accordingly, be called a product of imagination. This statement does not deal with the question of its objective reality; it merely asserts that ether comes into scientific experience in response to a demand for harmony in the ideational system, not through perception.

Critically constructed ideas are quite as valid as percepts or sensations.

The application to imaginations of practical tests and of the criterion of internal coherency has made it possible for man to carry his experience far beyond the ranges of direct perception. Too much emphasis cannot be laid on the fact that forms of experience can in this way be constructed which are just as useful, indeed much more broadly useful, than the simpler forms of knowledge which appear in percepts. The insight of the astronomer into the nature of the nebulæ is true, even though he has never visited the Milky Way. The principle of conservation of energy is true, quite as much as one's perception of the character of the object before his eyes. The conditions under which these more elaborate forms of experience are built up are different from the conditions of perception, but they are none the less legitimate forms of experience. The more indirect forms of experience have a different relation to activity and a different relation to sensory impressions than do percepts, but they are quite as worthy of attention. Indeed, in so far as they are the ripest products of the most highly developed forms of mental life, they are the most worthy objects of human study.

Uncritical imaginations.

The extent to which imaginations are criticised depends upon the development of the individual who possesses them and upon the type of ideas under examination. A good illustration of the dependence of criticism on individual development was given above in discussing the myths of primitive peoples. Another may be found in the imaginations of children. It has frequently been said that children are more imaginative than adults. This statement is based on the observation that a child will imagine many things in connection with its toys and derive a great deal of satisfaction from these imaginations, when an adult would be so clearly conscious of the falsity of the imaginations that he would derive little pleasure from them. This observation does not show that the child is more imaginative than the adult, but it shows that the imaginations in early life are not subjected to any careful criticism. Almost any mental combination is accepted by the child and enjoyed for the moment without serious criticism. Indeed, the child's experience is often like the savage's, too meager to make it possible for him to construct any systems of thought that shall constitute the basis for the criticism of his particular imagination. Furthermore, many of the child's activities are not sufficiently serious to constitute practical tests for his imaginative constructs. As life goes on and the systems of thought become more and more closely united with each other, and the practical demands of individual existence come to be more strenuous, the indulgence in fanciful imaginations unchecked by criticism becomes less common than it was in early childhood.

Literary imagination must maintain coherency.

An illustration of the way in which the same matter of imagination may be subjected to different forms of criticism is to be found in the case of literary forms. Literature is an effort to reconstruct before the imagination some system of thought which shall deal with human interests and human activities. If this reconstructive process purports to be held closely in agreement with certain records, we call it historical in character, and we demand that it shall conform to the

canons of congruity with all the legitimate records of the period in question. If the reconstruction is, on the other hand, confessedly free from any particular reference to definite situations, we call it imaginative literature and recognize its product as fiction. Even in this case we demand of literature that it shall have relation to experience, that it be recognizable as conforming to the general principles of experience. A wholly unnatural creation has no justification, even in fiction. The particular circumstances which are grouped together may be circumstances which never were brought together in the course of human history or individual life, but the principles of combination must be recognizable as principles in harmony with the general nature of human experience.

The looseness of literary criticism due to the complexity of experience.

The canons of criticism in literature are by no means as clearly definable as are the canons of criticism in scientific thought. The reason for this is clear; it consists in the great variation in the types of individual experience and the consequent laxness in the demand that the imagined experiences shall conform to the particular type of any individual's life. It is not difficult for us to accept certain rather grotesque and unusual combinations, provided these combinations of experience are referred to periods in time or points in space remote from those with which we are ordinarily in contact.

The uncritical forms of thought which preceded science.

The beginnings of what we call scientific thought are obscure, because the careful comparison of scientific ideas is preceded on the one side by much practical adjustment of activity to the environment, and on the other side by much uncritical speculation. The practical efforts to adjust one's activities to the world leads to certain systems of ideas. Thus, the child always looks for the causes of the happenings which come into his experience long before he formulates in clear, explicit thought the statement that every event has a cause. When he hears a noise, he has a vague notion of something back of the noise. In the same way men must have sought causes in practical life long before there was any science. They

had ideas which they used in the constructive activities of life, such as ideas regarding the strength and durability of certain building materials. While many of these general modes of thought were useful and contributory to true mental development, there were many other ideas which contributed nothing of permanent value or even hindered progress. Superstitions of all kinds flourished in the uncritical thought of primitive man. If a bird flew across his path, he thought of infinite varieties of good or ill. There is a certain sense in which all these superstitious and practical ideas constitute the beginnings of science. They furnished the thought material which, when sifted and organized into systematic form, constitutes science. The development of methods for sifting and organizing this thought content is one of the essential additions to thought which came with science. The sifting of this body of material depended upon the development of the ability to critically examine and compare all ideas.

Early critical forms of thought.

At first the critical faculty dealt only with the broadest questions, such as questions of the origin and destiny of life and of the world. In Greek philosophy, which grew up as a series of efforts to answer critically these large questions, there was something of science mixed with much of practical judgment and superstition. All forms of developed thought belonged together in this early period. Furthermore, a symptom which has very commonly been conspicuous in periods of critical thought appeared repeatedly among the Greeks; namely, the symptom of skepticism. When an individual begins to examine his ideas with a view to eliminating those which are incompatible, there is likely to be at first a very active rejection, amounting in some cases to a demand for total abandonment of what has heretofore been accepted.

Harmonious scientific ideas grew up first with reference to remote groups of facts.

When the systems of coherent ideas began to emerge from the original chaos of practical and superstitious constructs, it is striking that the facts remote from individual control were the earliest to yield to the organizing endeavors of thought. It was possible to

construct a system of consistent scientific ideas regarding the facts of celestial movement, because these remoter facts were far enough from individual life to be observed without perplexing minor incongruities. The nearer facts of any situation are too full of variations to fall into anything like an harmonious system without the most elaborate ideational reconstruction. Thus, a science of social relations and a science of mental processes could develop only after man had become so thoroughly devoted to the forms of scientific thought that he could follow the facts in long series, could deliberately assume some attitude other than that of direct personal relationship, and, consequently, could trace out certain abstract relations in the midst of the complex of varying elements.

The development of a scientific concept.

Let us consider briefly some of the scientific constructs which have been built up in the course of the development of physical science. Such a construct is called a scientific concept. Take, for example, the concept of the atom. Man found, as he examined the bodies about him, that these bodies underwent certain changes which were indicative of unperceived characteristics. It was important to understand these characteristics in dealing with the bodies for practical purposes. For example, water freezes, stones crumble, metals expand and contract with changes in temperature. Man must have noted many of these changes and many of their conditions very early in his dealings with such substances, but he had no direct means of observing what went on in the mass of the matter itself. He therefore set about, at least as far back as the early Greeks, trying to form some concept of the changes which must take place within the substance, in order to explain the changes which he observed. Certain of the Greek thinkers drew upon the forms of experience with which they were familiar; namely, their experience of composite matter made of separate parts, and formulated the concept that all substances are made up of particles which are separated by intervals of space. They concluded, further, that the particles which they assumed

as the elements of the substance, must be capable of greater and less separation from one another, as in expansion and contraction, and also that they must be capable of rearrangements, such that the appearance of the whole substance is modified without destroying the particles. Through such considerations as these, some of the early scientists came ultimately to refer to the smallest particles of any given substance as atoms, and to describe these atoms as separated from one another by space, and as constituting by their composition the observed body. The physicist or chemist to-day uses this very valuable concept in his thought about substances; he constantly refers to atoms, although he never expects that he will be able to see an atom, or to test the validity of his mental construct by the sense of touch. Indeed, the atom is a concept needed by science just because science has to bring together into an harmonious ideal system more than can be discovered in any single inspection or handling of an object. When such statements as these are made, some persons think that the validity of the scientific concept is seriously called in question. On the contrary, there is no higher guarantee for any form of knowledge than that it is demanded in order to render congruous the whole system of experience. As we have seen, in all of the earlier discussions of perception and ideation, experience has many higher phases which cannot be resolved into direct sensory elements. The validity of space as a form of experience cannot be called in question because it is a formal rather than a sensational phase of experience. For similar reasons, the construction of a concept is justified as a result of a higher organization of experience. The method of arriving at such an ideal construct is indeed indirect; but the concept has all of the validity which belongs to experience as an organized system.

Scientific principles as conceptual constructs.

A second illustration of a scientific concept, which it will be advantageous for us to discuss briefly, is the example of the concept which we call gravity. Man had long observed that bodies fall toward the

surface of the earth, and had fitted his activities to these observed facts of experience. In so far as he recognized that falling bodies are harmful, and in so far as he utilized certain missiles and tools to accomplish his purposes of attack or mechanical control, he had in experience merely perceptual processes; the concept of gravity was not fully developed through these direct adaptations of personal activity to falling bodies. The development of the scientific concept called for the comparison of a great variety of particular cases and the extraction from all of them of the idea of a certain general type of relation, which general relation is valid in each of the given cases and also has a general validity superior to any one of the particular cases. The law of gravity, which issued from this whole mental activity of comparison and abstraction, cannot be practically tested except in individual cases; we must depend for support for our scientific concept of gravity upon the analysis and comparison of these cases. When we have thus formulated and refined the concept of gravity, however, we have a concept in experience which can be regarded either as the essence of a single observable case or as a general statement of the common element found in every particular case.

Such concepts generalize experience.

Here again, as in the case of the concept atom, it is quite impossible to deny that gravity is a fact in the world, because our method of knowing it is indirect. Gravity is not a fact of sensory experience. The falling body may be seen or may be recognized through the sense of touch. On the other hand, its mode of falling may be separated from its other characteristics only by a careful conscious analysis of the sensory experience. When, however, a number of cases have been so worked over in consciousness, we may think of the mode of behavior in all of the cases under a single abstract term, which is no longer related merely to the single case, but represents the elaborate mental comprehension of all the cases through a single concept. The ability to develop such general abstract notions is the crowning achievement

of man's constructive ideational thought. It gives him certain formulas by which he can refer to a whole series of experiences in a single word or phrase. This word or phrase should not be confused with the name of a single fact; it is rather the name of an element of many different situations. It has been extracted from the concrete cases for the purposes of mental adaptation and has been formulated into a concept which makes it available, apart from any of the special cases in which it appears. When such a concept has been formed, its importance consists, not merely in the mental activity by which it has been developed, but also in the ability which its possessor exhibits to use the concept for further purposes of constructive thought and practical adaptation to his environment.

Distinction between imagination and conception.

Constructs of the type which we have been discussing are not usually described as imaginations. The image factor has become too attenuated, and the relational factor too important, to justify giving the construct a name which emphasized the image. Thus the scientist cares very little how one pictures atoms or gravity. He may for demonstration use balls for atoms and a wire for gravity. More important than these symbolical images is the relation which the concept expresses.

Concepts may be ends in themselves for the time being.

The formation of a concept is sometimes the end and sometimes the starting-point of mental effort. Thus, the scientist, working over a great variety of facts, is formulating a concept. He may have only the remotest interest in the use to which the concept is to be put; he is interested merely in refining and correcting his statement of the essential phase of reality which he is investigating. Yet, at bottom, the concept is dynamic. It may be for the moment an end in itself, but it is intended ultimately to determine some one's mental reaction upon a complex environment. The conceptual knowledge of the facts of experience may require time and effort for its development, but when it is once developed, the subsequent history of the mind which possesses

it will be determined by the new point of departure which the concept gives for conduct.

Judgment.

The application of a concept to any situation constitutes a phase of mental activity which is described by the term judgment. A judgment may be briefly defined as the mental process in which a concept is consciously related to another concept or to a particular experience. A judgment is usually expressed in a sentence.

Judgments can be understood only by reference to the concepts which they include.

Judgments differ according to the scope of the concepts which they include and according to the way in which these concepts are related to the other elements of experience. The conscious relating activity involved in any judgment is expressed in a copula, which joins together the two factors which enter into the judgment. Thus, in the judgment, "Man is an animal," the two concepts man and animal are related to each other, as indicated by the copula is. The question of how much is involved in a given judgment depends quite as much upon what is involved in the copula as upon what is contained in the terms, or concepts related. Very frequently the copula serves to suggest an elaborate relation which it only partially expresses. There has, accordingly, been great uncertainty expressed in the history of thought, as to the exact significance of such a simple judgment as that which we used a moment ago in the illustration, "Man is an animal." It has been contended, on the one hand, that such a judgment is merely intended to include the narrower concept man under the more comprehensive concept animal. It has been contended, on the other hand, that the copula suggests rather the relationship which the mind immediately grasps when it passes more or less clearly in review certain of the attributes of man and identifies them as included among the attributes of animals. According to this latter view, the judgment should be extended somewhat as follows: The being man has those characteristics of life and vitality and movement and sensitivity which are included also in the concept animal. In other words,

the judgment is here thought of as being full of ideational contents; whereas, in the first definition the relation between the two terms is thought of in as simple a form as possible. Man as a concept is considered in the simpler definition of judgment as a single fixed image or content of thought. Animal is considered to be a more comprehensive content of thought and the two are brought together in a simple relation by the copula is. This simpler account of judgments may have some justification in the fact that concepts, as they become more and more fully established, undoubtedly serve as abbreviated expressions of the relations which they embody. But no concept can be treated as a fixed content or entity to be put into another. As we have seen in our earlier discussions of ideas, concepts are not contents in any static sense of the word. Concepts are expressions of elaborate relations which have been worked out through the comparison and symbolical reconstruction of many individual experiences. A concept is, even in its most condensed form, an expression of many relations. When, therefore, one concept is brought into relation with another, it cannot be regarded as a mere motionless element of experience to be treated as a single image and placed in larger receptacles; it must be thought of rather as a relational fact which is for the moment compared with a second fact of the same fundamental order.

Degrees of explicit thought in concepts and judgments.

These statements regarding the relational character of concepts may seem abstract, but they will be comprehensible the moment one considers an example. What is in the mind when one thinks of an atom? Some image of a small particle of matter may be present as the content on which the mind rests, but this content is at once recognized as only partially representative of what is intended by the word. There extend on all sides of this image what James has picturesquely called fringes of thought. These "fringes" carry thought out to the other characteristics which are not pictured in the mental image. Thus, the scientist thinks of the elasticity of the

atom, of its indivisibility, and so on. It is not necessary to assume that in every case there is an image of a small particle of matter, nor that the mind works out explicitly all of the attributes involved. The image may be very meager. It is in many cases reduced to the written or articulated word. The consciousness of attributes is often reduced to mere attitudes, as pointed out in the earlier discussions of ideas. If one uses such words as "mass of matter," and "atom" in rapid succession, he can feel the transition from the "large" attitude aroused by the word mass, to the "small" attitude aroused by the word atom. It is in the treatment of concepts, perhaps, more than in the treatment of any other phases of experience that we must provide for many condensed forms of thought. That these condensations facilitate thought cannot be doubted. They permit rapid transition from image to image, reducing to the lowest minimum both the content of the image and the effort of transition. A judgment may also be a highly condensed form of experience. It would be a mistake to assume that the ordinary judgment is as full of explicit content or relation as it may be made if one dwells upon it and expands the ideas and the relations. But a judgment is, as contrasted with a concept, a fuller expression of the relational phases of thought. In a judgment, some transition from one idea to another is carried out and the transition is of sufficient importance to be expressed. There is always a distinct movement of relational thought in a judgment. The content phase of mental life, on the other hand, is not enlarged by the relational rearrangement which it receives in judgment.

Classification into positive and negative judgments.

With this dynamic view of the nature of judgments in mind, we may consider briefly some of their further characteristics. There are a number of classes of judgments which may be distinguished. In the first place, it is obvious that the assertion of a relation, as in a positive judgment, and its denial, as in a negative judgment, must be of diametrically opposite values in any process of thought or reasoning. If we say that man is not a mineral, the significance

of this judgment for all later mental activity is very different from the significance and value of any judgment which aims to establish affirmatively some type of relation between the two facts in question. To say, for example, that man finds metals in the earth is to establish a positive relation between the two concepts which were a moment ago distinguished as separate from each other so far as the relation of identity is concerned. Positive and negative judgments are, therefore, treated as two of the general classes which must be distinguished in the study of judgments.

Relations in many respects partial.

Again, judgments may be distinguished by the degree of the universality of the relation under discussion. Thus, if one asserts that some men are artisans, the relation between the class men and the particular type of occupation mentioned, is asserted as only a partial relation, and that fact is made perfectly clear in the form of the statement itself. There is a certain secondary limitation placed upon the thought which is not so obvious from the form of the statement as is the limitation implied in the word "some." The predicates of most affirmative judgments are included in the thought, only in part. Thus, in the judgment used as an example, not all artisans are referred to. There may also be women who are artisans. In other words, the term artisan is not exhausted by being placed in the relation in which it is here placed to the concept man. Most affirmative judgments are partial in respect to their predicates. In negative judgment the relation is cut off in both directions; hence, the predicate as well as the subject is exhaustively treated. "Men are not plants" is negative with regard to both classes.

Judgments are universal or particular.

The limited character of most affirmative judgments can be illustrated by contrast with mathematical judgments. It is a peculiarity of such judgments that they are reversible. To assert that five is equal to three plus two is exactly equivalent to the assertion that a quantitative relation exists between five and the other two numbers, such that the relation is the

same from whichever side of the equation one begins. For most of the judgments of practical life, the relation is not the same when viewed from opposite points. This is evidenced by the difference which is always recognized between subject and predicate. The subject of the judgment is, in a measure, put in the place which would be occupied by the speaker if he himself were to assume some sort of relation toward the predicate. The relation is, therefore, commonly viewed from the point of view of the subject of the sentence. When we attempt to view the same relation from the point of view of the predicate, we are likely to find that the ordinary judgment is not reversible, because, as pointed out above, the relations involved in the predicate concept are only partially exhausted. Take, for example, one of the general judgments that we have already used for illustration. It is true that all men are animals, but it does not follow at all that all animals are men. The universality of a judgment is, accordingly, defined, as stated above, with reference to the comprehensiveness of the subject. If the subject is treated in all its phases, the judgment is classified as broad and universal. If the subject, on the other hand, is definitely limited, the judgment is also regarded as limited, and is known as a particular judgment.

Reasoning in syllogistic form consists in a combination of judgments.

Turning now from judgments to the more comprehensive combinations which are worked out in thought, we find that two or more judgments may be combined in such a way as to build up even more elaborate systems of relations. The process of combining judgments is known as the process of reasoning. For example, if we use the classic illustration of formal logic, we may assert that all men are mortal, that Socrates is a man, and, therefore, Socrates is mortal. Such a series of judgments constitutes the simplest complete cycle of reasoning, and is known as a syllogism. A complete syllogism consists, as will be seen, of two judgments which constitute the premises and a third judgment which appears as the conclusion of the reasoning. Such a simple syllogism must contain three

terms, and three only. The reason for this limitation upon the number of terms is obvious when we consider that the purpose of the syllogism is to relate two of the terms through their relation to a common middle term. The middle term must appear in each of the judgments in order to furnish a link by which the judgments may in turn be united with each other.

Reasoning deals with series of relations.

The mental process involved in such a syllogism will be manifest if we apply the analysis of judgments which has been given in earlier paragraphs. To assert that man is mortal, is to assert that a certain definite characteristic is found in man and is expressed in the general concept mortality, which is applied to man in the judgment. When it is asserted in the first judgment that all men exhibit the characteristic or group of characteristics referred to in the predicate, it is easy to see that any particular man must be thought of as exhibiting the particular characteristic which has been explicitly referred to as belonging to all men. In the conclusion, Socrates and the attribute of mortality are related, not because of any observations made upon Socrates, but because the experience of the thinker and of the race has settled upon mortality as a general human characteristic.

Deduction and induction.

There are different forms of reasoning according to the differences in the points of departure and the differences in the modes of working out relations in experience. One general difference which has been long recognized as of cardinal importance is the difference between deductive reasoning and inductive reasoning. Syllogistic reasoning has commonly been recognized as the simplest and most complete example of deductive reasoning. Deduction is defined as the process of applying a general principle to a particular case. Induction, on the other hand, is a process of building up a general principle from particular cases. The application of the general principle of human mortality to Socrates would constitute a case of deduction, while the derivation of the general principle that all men are mortal, exemplifies the inductive process in which many particular cases of human mortality are

all summarized in the general conclusion that all men have this characteristic.

Deduction and induction usually united.

Most thinking is not entirely deductive or inductive in form; there is a play of the mind from familiar general principles to new applications and from the new applications to the establishment of new principles or the modification of old ones.

Concepts, judgments, and reasoning are all phases of the same general type of mental activity.

Reasoning, like judgment and like the process of arriving at concepts, is an elaborate working over and rearrangement of experience. Indeed, it is quite impossible to study the three forms of mental elaboration involved in concepts, judgments, and reasoning, without recognizing that there are no hard and fast lines between them. Very often reasoning is cut down so that it becomes simple judgment. Again, the mental processes which may be for one individual who is trained in thought mere conceptual processes, may require on the part of a less trained thinker the most elaborate and painstaking reasoning. The reasoning of a highly trained scientist is very often so compact as to be quite beyond the reach of the ordinary thinker.

Science is systematic ideation.

Science is, when defined in the light of this discussion, an effort to develop a coherent system of concepts which shall systematically record the essential relations presented in experience. The scientifically trained mind is supplied with a large number of ideational relations which serve as guiding suggestions, and any new situation is therefore analyzed with greater ease, because the scientist goes more directly about his search for the essential relations involved. The ability to abstract from confusing details, and to concentrate attention upon recurring general relations, comes to be a habit of mind. We are justified, accordingly, in speaking of an analytical and scientific mode of thought. In such a phrase we are obviously not referring to content factors in consciousness, but rather to forms of rearrangement and organization within experience of those contents which are for the most part the same as the contents presented in ordinary consciousness.

The analytical character of science is well shown by its devotion to experimentation. An experiment

consists in the careful preparation of the conditions under which a given phenomenon appears, and the subsequent deliberate modification of certain of these conditions. An experiment is thus merely an objective form of analysis. In general, it may be said that the manipulation of conditions is the means employed to aid in building up an idea of the essential relations, these being more easily seen when they are varied independently of the other phases of the situation. Thus, if it is found that the movement of a magnetic needle is affected by the withdrawal or approach of a coil of wire carrying an electric current, then the relationship between magnetism and electricity obtrudes itself upon the observer in such a way as to make the relationship easy of discovery. There are certain cases in which the relationship cannot be discovered without some such deliberate modification of the conditions, because the whole situation is so complex that there is no possibility of a purely mental analysis of the situation. For example, when a sensory stimulus enters an animal's body, it cannot be directly traced through the complex tissues; its effect can, however, be ascertained by experimentation, as when we give a particular stimulus at a prearranged moment and observe the effects by means of some method which records the motor effects of the excitation.

Experiment is analysis both in thought and practical manipulation.

A second method of scientific discovery, which also indicates the importance of analysis, is that which consists in bringing together a large number of cases of the phenomenon under investigation. If many cases are brought together, there will appear certain uniformities and certain variations in the individual cases, and these can be utilized in distinguishing between the essential and unessential factors of the phenomenon. Wherever a certain factor or relation occurs only in a few cases of the phenomenon and is absent in many, we recognize it as purely accidental and insignificant for the particular investigation in hand. On the other hand, a factor or relation which is always present requires more serious consideration. If, after this simpler form of comparison, the factors

Comparison as an aid to scientific analysis.

or relations which are always present can be further investigated, and it can be shown that in certain additional cases the phenomenon is always absent when the factors and relations under consideration are withdrawn, then these necessary factors and relations come to be regarded as essential.

Mass of material does not assure scientific generalization.

These methods of analysis by positive and negative comparison should be clearly understood to involve a large element of thought analysis, in addition to mere observation. The mistake has sometimes been made in empirical science of believing that the accumulation of facts constitutes in itself supreme scientific attainment. This notion can be refuted by an appeal to the history of science. The great movements in the world of science originate in broad generalizations which constitute the conceptual and ideational formulation of observations. The formulation, to be sure, could not have been made without content, but the discovery of a broad general relation is a higher form of achievement than merely recording observations, that is, presenting new contents.

The number of cases necessary for a scientific analysis need not be large.

It has always been one of the most difficult questions of scientific method to decide how many cases are required to establish a scientific principle. For example, how many cases are necessary before the conclusion that gravity operates between all bodies can be thoroughly established in science? If one asks such a question as this, it is not unlikely that he is committing a fallacy by assuming that the amount of material upon which the principle is based determines the validity of the principle. He will be likely to answer his own question in that case, by saying that there is no final certainty until science has exhausted all of the possible circumstances under which the phenomenon may arise. The collection of all possible cases is, however, impossible in view of the fact that there are future cases of the phenomenon which have not yet arisen and which therefore cannot be subjected to present scientific study. As a matter of practical fact, science does not wait for the collection of great numbers of cases. It waits only for the discovery

of a principle which is thoroughly valid in any given case. If science can discover a definite relation by the careful scrutiny of a single case, the principle which it discovers is valid, even though it was discovered without attempting to accumulate all possible cases. The answer, therefore, to the question, how many cases are necessary for the establishment of a principle, is that just so many cases are necessary as are required to make clear the type of relation which is involved between the facts under investigation. Newton undoubtedly did more for the establishment of the principle of gravity by the clear demonstration of the operation of that principle in the relation between the moon and the earth, than could have been done by the addition of five thousand cases of the operation of gravity on the earth's immediate surface. An analysis of a single crucial case is very frequently enough to establish a scientific principle of great generality. The crucial character of the case is to be found, not in its own immediate scope, but rather in its appropriateness to the analysis in hand.

Logic and psychology.

The foregoing discussions have led us far into the domain of logic. It is the function of logic to classify judgments, describe modes of reasoning, and discover the norms of correct and valid thought. The work of logic has sometimes been done without a preliminary psychological analysis, such as has been taken up in the foregoing paragraphs. Logic becomes then merely a record of what have been found in practical thought to be correct modes of thinking. The norms which it lays down can be tested, but they cannot be explained. Explanation depends upon psychological analysis. The function of psychology is not to discover the laws of correct reasoning, but rather to supply the analyses which shall make the discoveries of logic intelligible. Logic is thus the formal science laying down the norms or laws, while psychology is the explanatory science dealing with the phenomena in such a way as to discover their characteristics.

The tendency in some quarters has been to look upon the laws of reasoning and judgment as beyond the

Even the higher intellectual processes have physiological conditions.

scope of psychology, as superior to all the known conditions of mental activity. The foregoing discussions show that reasoning is nothing more nor less than an elaborate form of organization of experience. Step by step our discussions have led us from the simplest and most direct elements of experience, namely, sensations, through various forms of arrangement, through certain indirect types of reproduction and reorganization, to the complex processes of combination found in judgment and reasoning. Indeed, we may assert that these highest processes have physiological conditions of a type with which our previous study has made us familiar.

Physiological conditions of higher mental processes.

The complex associational processes in the cerebrum are related to the higher forms of conception, judgment, and reasoning. Whenever a stimulus causes an impression which in turn arouses a train of thought, there is a period of delay during which the sensory impression is much elaborated through association. This shows itself in the fact that the excitation is not immediately discharged through the motor centers in the form of a reaction. The delay due to associative organization may extend over minutes or hours or even days. Some of the impressions received into the cerebrum are utilized only after the most elaborate reorganizations. It is in connection with these more elaborate processes of reorganization that the higher forms of conceptual activity appear. We do not know in particular cases the special nervous structures or processes involved, but it is certain in general that the relations exhibited in these higher forms of thought are conditioned by physiological processes in the indirect association areas of the cerebrum. The most important fact for our consideration is that they are not direct sensory processes, but processes of reorganization.

Ideational processes are accompanied by feelings.

These indirect neural processes have relations analogous to those discussed in treating of the harmony and conflict of motor processes. We know from introspection that when the tendencies of thought aroused by two concepts or judgments are congruous, there is a distinctly pleasurable feeling in experience. When,

on the other hand, there is hesitation or doubt due to conflict among the processes of thought, there arises a feeling of displeasure. When a new concept or judgment fits into the thought of the subject so as to promote that thought and carry it forward to its issue, there is marked attention. When a new concept has no significant relation to the individual's modes of thought, it will be neglected. These introspective facts are so closely related to those which appeared in the study of feelings and attention in connection with percepts, that we must assume for the higher feelings the same type of neural conditions as those which underlie sensory feelings.

Evidences of the direct character of these feelings.

The feelings which attach to ideas and judgments and reasoning are in many cases very obviously related to nervous processes which lead to immediate bodily movements. The facial expression and tone of voice often exhibit the exultation or depression which accompany successful reasoning processes, or they exhibit in other cases doubt and inability to solve the problem in hand. The experience in such cases is a complex involving indirect conceptual processes and direct attitudes accompanied by direct forms of bodily activity.

Ideas about feelings may or may not be accompanied by direct feeling elements.

Whether there are indirect attitudes not related to bodily responses of some kind is a question the answer to which will depend upon the meaning of the term indirect attitude. One can very easily construct an idea of himself in a pleasant or unpleasant situation. If the idea becomes vivid, it is likely to arouse a direct attitude accompanied by expressive activities appropriate to the ideated situation. If the idea is not vivid enough to become a subject of direct concern to the thinker, then there may be an idea of the feeling without the feeling itself. In general, then, we may conclude that there are no indirect attitudes as there are indirect forms of ideational experience. All feelings are direct even if they grow out of agreements or disagreements between ideational processes.

The complex character of all the higher forms of feeling and attention depends upon the complexity

Grades of attitudes depend on content.

of the relations out of which these attitudes grow. We speak of our ideal feelings and of our finer emotions and hold these to be superior to our sensory feelings. The distinction is more a distinction of matter and complexity than of the feeling state itself.

Emotions and sentiments.

These discussions show how little ground there is for a new classification or description of the so-called higher feelings. Sometimes the word "emotion" is used to refer to the feelings related to ideas. The word "emotion" is in other cases used to designate a complex group of experiences. Thus, pleasure would be described as a feeling, while æsthetical satisfaction would be described as an emotion, both on account of its complexity and on account of its relation to higher forms of experience. The word "sentiment" has sometimes been used to designate the emotional attitude toward the higher concepts. Thus, reverence, admiration, and awe are higher sentiments.

Belief.

There is one type of experience which has been variously classed as an idea, an emotion, and a tendency toward behavior; that experience is what we describe by the term belief. There is justification for each of these classifications. Belief as a form of thought grows out of the harmony between a present idea or percept and earlier ideas or percepts. Thus, one can believe any suggested idea which does not conflict with past experiences. Belief is a form of feeling, in that it is related to the attitude of acceptance which attaches to the given idea when it fits into experience. The idea may be painful on the feeling side, because it does not fit into the plans and hopes of the individual, but it is believed, because it fits into the other experiences so completely as to demand that it be accepted as true. Finally, belief, like every other aspect of experience, is related to behavior, either present or potential. We act on our beliefs, because these are the accepted forms of organized experience, or in any event we guide our conduct either affirmatively or negatively by what we organize into the sum total of experience. Belief is thus seen to be a name for the general fact that certain experiences are organized

in harmony with one another and are accepted as the basis of individual attitudes and of individual conduct.

Problem of psychology with regard to the higher feelings.

The discussion of the higher feelings or emotions could be extended without limit, for there are as many types of emotional attitude as there are concepts and ideational relations in mental life. The relation of psychology to the feelings differs somewhat from the relation of psychology to concepts. It is not the duty of psychology to discuss all of the concepts. Physics deals with one group of concepts, chemistry with another, biology with another. The business of psychology is not to attempt to duplicate the work of those special sciences, but merely to indicate the origin and character of all conceptual processes. There would be more justification for a catalogue of the emotions in a text-book on psychology, for they are forms of consciousness growing out of interrelations between various ideational and perceptual experiences. But the description of special feeling attitudes may be left to literature and the fine arts and to the related sciences of æsthetics and ethics. It is the duty of æsthetics to deal with the sentiments and attitudes related to the concept of the beautiful, and the duty of ethics to deal with the moral sentiments. The work of psychology in this sphere may be regarded as completed with the general outline of the nature of the emotions and the presentation of a few illustrative cases.

CHAPTER XII

THE CONCEPT OF THE SELF

The self as a most fundamental concept.

AMONG the concepts which are built up in practical life and refined by scientific study, there is one which is of special significance to the student of psychology. It is the concept of the self. So significant is this concept for our ordinary behavior and thought, that many have regarded it as immediate in character and as much more fundamental than any other concept. Indeed, there are some who are prepared to say that the recognition of the self is even more direct than the process of conception; that the self is a kind of directly perceived entity; that there is no stage of mental life in which there is not an immediate recognition of the existence and significance of the self.

The self is a developing and unique type of reality.

When we study the development of the individual, it is obvious that the statement just referred to, that every human being has a direct recognition of the self from the first, cannot be seriously considered by any-one without the qualification that the degree of this immediate consciousness of the self is not the same in early childhood and in mature life. The child unquestionably does not recognize himself in any such clear way as does the mature adult. If the mature individual is asked what constitutes his own self, he is able to refer to certain leading characteristics of his personality which obviously could not be known or recognized by the child. There is, therefore, ample justification from any point of view for the discrimination of several grades of developing selfhood, and whatever his general position, the psychologist must define these successive grades of development as varying degrees of self-consciousness. The development of self-consciousness differs in one important respect

from all other forms of consciousness. No new physical fact is developed in the world through the development of an idea of matter or of physical bodies, but when the consciousness of self grows, there is a change in the nature of the self. There grows up in the midst of mental life a fixed center of dispositions and tendencies of thought, which in time not only comes to be recognized as distinctly different from the outside world and from the centers of interest and thought in other personalities, but also becomes more fixed by virtue of the fact that it is thus clearly recognized. This central core, which constitutes the intimate self of every individual, is quite inexplicable without reference to development. Such consideration of the development of the self as the center of personal interest and personal attitudes, lays the foundation for the discussion of the scientific concept of the self which grows out of our psychological study. Furthermore, it gives to the self exactly the same scientific standing as belongs to atoms or gravity or any of the other conceptual generalizations of the sciences. The mistake has often been made of demanding a perceptual account of the self. The experiences of life are the perceptual manifestations of the self, just as ordinary percepts are the manifestations of matter. Matter can be reached only by conceptual thought-processes. So also with the self, it can be reached only through conceptual generalization.

Primitive experience undifferentiated.

Let us attempt to formulate what we know of the most primitive stages of individual experience, in order that we may arrive at some notion of what experience is like before there is any recognition of the self as a conceptual center of this experience. The simplest forms of animal behavior do not indicate any large degree of discrimination between the factors of impression, nor any clear marking off of impression from expression. The activity which follows upon impression is so direct that there is no time for the interpolation of any factor between impression and expression. Much the same kind of situation appears when we examine the human infant. There is an inherited

mechanism in the instincts which supplies appropriate responses to certain stimuli, but there is little conscious discrimination on the part of the individual. Furthermore, the instinctive attitude is so highly organized at the first that there can be little reason for the discrimination of sensation from response. Rather must it be true that sensation and response blend in an experience which is overwhelmingly responsive in character and little discriminated into elements. Such experience demands no conceptual elaboration.

Differentiation of factors the condition for all later forms of experience.

The development from this point must be toward the discrimination of phases of experience. Probably there is a gradual differentiation of the sensory elements from one another and of the sensory elements from the individual attitudes and responses. Even perceptual life cannot go forward without the recognition of experience as made up of elements, some of which can be centered about objective nuclei to constitute what we have called the unity of things. As soon as things begin to be recognized, there must be a tendency to formulate all the attitudes toward things into a kind of personal unity or self. The construction of such an idea of a self in contrast with things is a slow and complex process.

Child's early notion of self largely objective.

Undoubtedly, a child's contact with his own body is very important in building up some early crude distinctions between impressions and attitudes. When the child handles his own feet, he finds that the impression he receives, and the attitudes into which he is thrown by the double stimulation of two parts of his body, are entirely different from the impressions which he receives and the simpler attitudes into which he is thrown by the stimulation of one of his members through some external object. He thus comes to distinguish between his body and the external world in the course of the development of his experiences. The body is a part of the world with characteristics different from the other factors which he recognizes through his senses. There is probably some ground in this fact for the statement that the child's earliest recognition of himself is of the nature of a percept and

relates to his physical organism. It is certainly true that children apply the first personal pronoun very early in life to objective facts which pertain directly to themselves, especially to their bodies. The relatively objective character of the experience of self at this stage is shown by the fact that, in addition to his own body, the child attaches to himself, as a part of what he calls himself, the possessions which he comes to recognize as his individual property. The external world is broken up into the *meum* and *tuum,* and the general notion of that which belongs to the individual himself is gradually distinguished from that which belongs to others, but the *meum* is not primarily a subjective fact. It is looked at through consciousness, but that consciousness is very little self-consciousness in the abstract and purely subjective sense in which we use that term in mature life.

The idea of self comes only with discrimination of objective and subjective.

Such considerations as these tend to show that the general idea of that which pertains intimately to self is a product of discriminative analysis, rather than a fact of primitive consciousness. So far as we understand immediate consciousness in its early stages, there appears to be little or no ground for assuming that there is present any complete discrimination of the self on the one hand and things on the other. Even in mature life the distinction between the self and non-self is not always drawn. The man who is hurrying to catch a street-car has a vivid experience, but it is not nicely analyzed. The hungry man with food before him is little more self-conscious, if indeed any more self-conscious, than the animal which spends all of its time and energy in the eager pursuit of food.

All discriminations contribute to the development of the idea of the self.

Evidence of the lack of clear discrimination between things and the self is to be found in the fact that in primitive human life the attributes which later will be consolidated into an idea of the self, are confused with external physical facts. In other words, when ideas first begin to be formed of things and of the self, the two types of ideas are not clearly distinguished. The self is thought of in distinctly materialistic terms, while external objects are thought of as having personal atti-

tudes and personal characteristics. Savages show a tendency, as was pointed out in an earlier discussion, to personify everything, and children show the same tendency. To the savage every natural phenomenon is the expression of some personal will. Every object with which he comes in contact is, like himself, a person full of emotion and resentments. The process by which this undifferentiated world is broken up into clearly contrasted things and the self, is the total process of mental development. The child sees that things do not change with his changing attitudes toward them. There are certain attributes of experience which do not respond to his most violent efforts; these he objectifies and comes to contrast with his personal attitudes, which are closely related to his experiences of effort. Every step in the definition of the outer world is a step in the definition of the self. With the rise of social relations the opportunities for developing ideas of the self are greatly increased, because other selves are at once analogous to the personal self and yet sufficiently contrasted with the personal self to give sharply distinguished character to the purely personal interests which constitute the discriminated self.

The self is discovered by contrast with not-self.

What brings any individual to a clear recognition of himself will probably depend upon the accidents of individual fortune. The struggle of personal interests with some unyielding objective fact may accomplish it. The development of an idea of some other self, opposed in interest to the self, is often a powerful incentive to the recognition of one's own self. Historically, it has repeatedly been pointed out that the national spirit, which is analogous to personal self-consciousness, often grows out of some contest. In like fashion, the clear idea of the self undoubtedly rises out of some contest of opposing interests. Indeed, the transition from another self to one's own self is so natural that one finds that he continually represents himself in his own thought as a kind of outside personality who is being observed in an objective way. Whatever may be the mode of sharp

differentiation of the self from the rest of the world, it is an event in mental development, not a primary fact.

The various selves.

That the development of the concept of the self depends upon the circumstances of experience appears from the fact that the different accidents of life lead to the development of a series of different aspects of the self. Professor James has vividly described this phase of development by saying that we are all of us composite selves made up of the social self, the business self, the literary self, and so on through the full list of our activities and interests. The business self is that compact group of intimate experiences and personal attitudes which are distinguished and represented in the form of a clear idea whenever we find ourselves called upon to think of our relations to certain commercial transactions. If, for example, some one makes me a proposition with regard to the purchase of a house, I am immediately led to consider all of those personal concerns which would be involved in such a transaction. I do not, for the moment, think of the scientific interests which might have been aroused by some reference to the department of educational activity in which I am engaged. In other words, the organization of our experience into near and intimate phases, and the development of contrasts between these near and intimate phases of experience and those phases which are more remote, is a process of differentiation. Early experience contained some of the elements of this contrast between the self and the external world, but the working out of the contrast in all of its ramifications is the result of experience. On the physiological side, there are, of course, at all stages of existence the individual nervous system with its processes which are distinct from the processes in the material world, but the self as a unique fact in consciousness does not rise through the mere separate existence of processes in an individual body. The true self is the being conscious of his own place in the world. There may be a separate physiological being without self-consciousness, as when one falls asleep, but this is not a true self. Only in so far as the self

is recognized as a system of experiences or processes does it have definite character. The consummation of the conditions which make possible personal selves is, therefore, the development of a compact group of relations into a single idea or concept.

Contrasts between the attitudes of different selves powerful incentives to self-consciousness.

One of the chief conditions for this development of a self-conscious personality is, as pointed out above, the social distinction between one's own personal attitudes and the personal attitudes of other individuals. If two individuals stand in the presence of exactly the same fact of external experience and find themselves assuming toward this experience attitudes which are totally different from each other, there will be a powerful motive for both individuals to give a higher degree of attention, not only to the fact at which they are looking, but especially to their own ways of responding to this fact. This personal character of individual response is, therefore, constantly forced upon one's attention through his relations with the social world. The contrasts of selves is largely dependent on the use of language. One sees that all the words referring to spatial directions, for example, center about his own body and about himself. One finds that he uses active or passive verbs in an entirely different way than could his neighbor. One finds, in short, that his expressions are arranged and organized around a different center than are the expressions of every other human being. So impressive does this contrast between individual attitudes become, that ultimately, when we find ourselves in agreement with others, we are impressed with the agreement, as in earlier cases we were impressed by the differences, in mental attitude. The result is that our contact with the social world is a constant stimulus to the development of a more and more clearly defined recognition of the self. The child undoubtedly comes to self-consciousness through his use of language more than through any other means.

The self not primarily a scientific concept, but a practical concept.

Some idea of the self, based upon discrimination of one's own attitudes from the attitudes of other persons, is developed in a wholly unscientific way by every individual, just as the discrimination of the

individual body and the individual possessions from the rest of the physical world arises naturally in the course of personal life without any effort at systematic definition. Beyond this natural discrimination, one may attempt to cultivate a more highly refined formulation of his personal attitudes and personal characteristics, and yet not pass directly into science.

The cultivation of personal attitudes.

To illustrate certain cases in which elaborate ideation takes a form other than the scientific, we may refer to certain phases of literary criticism. If one begins the criticism of any piece of literature, he will constantly be contrasting the impression which the author intended to produce with the personal attitude aroused in himself through the statements which he reads. There will thus be a certain social contrast between the individual and the author, and this will not be dependent upon the mere accidents of ordinary life, but it will be deliberately cultivated for the purpose of refining and critically elaborating one's own taste. In some cases this may take the form of an effort to conform these personal tastes or attitudes to the standards which have evidently been adopted by great masters. There is here an unquestionable tendency to refine the notion of the self at the same time that one cultivates attitudes toward the objective facts.

The religious motive for self-consciousness.

Another illustration of the non-scientific cultivation of the concept of the self will appear if we refer to the attitude which is assumed by many individuals in the contemplation of their own origin and destiny. The religious attitude has undoubtedly contributed more to the definition of self in the minds of unscientific individuals than any other system of thought or activity in the world's history. One here asks himself, not what is his relation to the canons of taste established by master writers and artists, but rather how fully his own personal attitudes conform to what he understands to be the demands of the laws governing his destiny. The system of laws, which he accepts as a system of higher law, may be derived from very different sources, but in any case, whether it be the

religious faith of the savage or the systematized theology of the most highly cultivated devotee of an elaborate religious system, there is always in religious thought and aspiration a comparison between the demands of the religious system and the demands of individual interest and feeling. The notion of the self comes to have a compactness and importance under this system of religious self-examination which it could never attain by mere social contrast with the experiences of other individuals or in the presence of physical objects. Questions of ultimate destiny arise, and these are answered in terms of a self which is much more highly elaborated than the bodily or material self upon which man concentrates his attention in the early stages of individual life or the primitive stages of mental development. We find, however, many indications, as we look into savage customs, of a curious mixture of the primitive bodily self and the religious self. The savage always protects with great care the bodily remains of those whom he would serve, and he mutilates and destroys the body of an enemy. He very frequently goes much further than this and attempts to preserve, with a view to the enrichment of future existence, those material properties which in this life have constituted the broader self. Such crude expressions of the effort to develop a single, coherent self, as these which we find among savages, are paralleled in much more highly refined and ideal forms in the notions of individual selfhood and of what is essential to this selfhood in the more abstract beliefs and usages of civilized peoples.

Theological concepts of matter have exercised large influence upon the development of science.

The influence of theological and religious conceptions has been apparent even in the older physical sciences. For example, there was in the mediæval religious world a very definite attitude which tended to regard matter as a form of reality opposed to all the better phases of spiritual life. This degradation of matter was undoubtedly related to the desire to give the highest possible position to the concept of the spiritual self. These mediæval conceptions of the nature of matter impeded for a long time the development of natural

science, because they tended to turn the interest of men away from material processes. Indeed, physical science was at one time treated as impious, and was rendered by social prejudice dangerous to the lives of those who took it up. But physical science succeeded in overcoming this prejudice by steady reconstruction of the fundamental conception of matter. It examined the phenomena in the material world; it discovered the essential relations which appear in these phenomena, and gradually formulated itself into a system of concepts more applicable to the real facts of experience than the earlier dogmatic concepts which were formed without this close reference to empirical facts. There is no disposition in modern physical science to limit the reconstruction of its concepts of matter; there is rather a clearly conscious disposition to include as broadly as possible all of the elements which can be discovered. The theological concept has been reconstructed in conformity with this scientific attitude, and the influence of theological concepts is no longer opposed to physical science.

The self intimately related to religious belief.

The religious demands were much more keenly felt when the concept of the self was in process of formulation. The immortality of the self was of much greater interest in mediæval times than the processes of sensation and perception. Indeed, the religious conception of the sacredness of the self extended even to the body, and was undoubtedly one of the most potent forces in preventing the development of scientific studies of anatomy and physiology. It is not until a comparatively recent date that the science of the physiological organism and of psychological processes could break away from all presuppositions and dogmas and begin the careful collection and formulation of the facts on which to establish strictly scientific concepts of man's physiological and psychological relations.

The duty of psychology is to formulate a concept of the self.

The function of psychology is to formulate a scientific concept of the self. This can be done without ignoring other formulations of the idea of the self and at the same time without bringing the scientific concept into subservience to these other ideas. It is, as all

the foregoing discussions have shown, the duty of psychology to ascertain the laws of mental activity, such as the laws of perceptual fusion and ideational organization. As a result of such scientific studies, the modern scientific notion of the nature of knowledge is as much clearer than the notions held in earlier times, as the modern physiological notion of blood circulation is clearer than the earlier conceptions of bodily nutrition. It may be stated of the self, as of the conception of the material world, that there is to-day a larger body of facts on which to found definite concepts than at any other period in history. That this modern effort to formulate a concept of the self has brought out defects in the earlier concepts, no intelligent student of history can deny. For example, the concept of the self as independent in its development of bodily organs, can certainly not be defended in view of our present knowledge. The notion that the self is absolutely free from the operation of laws is another impossible concept. The full development of a self-consistent concept of the self is by no means an easy task, but it should not be given up because it involves the revision of certain time-honored concepts built up on other foundations, nor should it attempt to ignore these earlier practical formulations as absolutely useless.

The full concept of the self must include every possible relation.

The best adjustment of all disputes will be attained if it is recognized that the final definition of the concept of the self is not a task for any one system of analytic thought. The analysis of the self out of the total complex of experience demands attention to many lines of discrimination. The formulation of a scientific statement of the self cannot be a substitute for formulations of the practical sort, which grow up in the various contacts of the individual with his physical and social world. A fundamental difference between the concept of the self, and the concept which one forms of matter, appears in the fact that the self is ultimately the center of all possible forms of relationship. Experience is engaged in working out the relation of the self to other selves, to the physical world, to moral demands, to literary ideals, to all other phases of

known reality. The nature of this central nucleus of all of these different relations must, therefore, be defined in terms of all the different groups of relations. The ordinary view is of the self as a center of one particular group of business or social relations. Such a partial concept should be recognized as incomplete. The self is very much more elaborate in the possibilities of its relations than any other form of reality considered in science. It is characterized, also, by a unique type of activity which we do not know to exist in any of the forms of reality about us, other than personalities like ourselves. This type of activity we describe when we use the word "consciousness," although this word "consciousness" is a name for so fundamental a form of activity that one can get a direct recognition of its significance only by looking within himself. The ultimate conception of the self must, therefore, make room for all of these different elaborate phases of interest and relation, and for the unique characteristic of consciousness. The self is at once a center of relations and the consciousness of these relations.

The self is characterized by unity in spite of certain difficulties which this concept presents.

One of the chief characteristics of the self, as conceived according to the principles of science, is its unity and organization, as distinguished from the factors which enter into it. This unity of the scientific self stands somewhat opposed to the disintegrating tendencies of the various interests to which reference has been made. The self, as scientifically conceived, must be recognized as including in some fashion all of the minor selves. When thus considered, the provision for the devotion of the unitary self to different kinds of interest at different times must also be adequately provided in the scientific definition. The unity of the self is, therefore, not a constant and complete unity; it is rather a unity with phases which are susceptible of more or less emphasis at any given moment. The social self may give way at any given time to the business self or to the literary self. The religious self may be for the time being in abeyance and the political self may be the dominating group of interests. The question immediately arises, there-

fore, Where are the unemphasized phases of selfhood during the emphasis of one or the other group of interests? It is because of the necessity of including many selves in the central self that the concept of memory has played the large part which it has in all psychological discussions of the subject. The assertion of a retention of each of the earlier forms of experience in the self in some sublimated form of subconsciousness or unconsciousness has often been suggested as a solution of the difficulty. Sometimes it has been argued that the effort to hold together the concept of unity and the concept of consciousness must be frankly given up. Consciousness is a point and, by its very nature, excludes, it is said, the total unity. The unity must be sought in the non-conscious conditions of consciousness, in the physiological self. This view is refined into the statement that it is the brain which is the seat of unity. As certain parts of the brain are aroused to activity, one or the other self appears.

The imaged self as a concrete foundation of the concept.

These suggestions are in keeping with the natural tendencies of thought which seeks some concrete image as the basis of every concept. Men have always sought some concrete image of the self. It is a ghost, or a breath of air, or a body, or brain, according to the degree of culture of the thinker. Whatever it is, the image is useful in exactly the same way as an illustrative ball is useful in explaining the concept of an atom. The ball gives the content to which the relations which constitute the essence of the concept may attach. So the attributes of the self may be grouped around the image of the physical self or around some imaginary being, such as a ghostly self. The danger of using such an image lies in the fact that some persons will mistake the image for the concept. The concept is, however, more than the content factors which enter into it. The concept, as we are prepared by earlier discussions to recognize, is composed of a series of relations which attach to the content factors and constitute the essence of the concept. The conceptual unity of the self is superior to anything which can be imaged.

When we consider the matter closely, the supposed unity of the brain dissolves into a complex, and its functional processes are recognized as many. The unity which we attribute to the brain is transferred from the unity of experience to the brain, which is thought of as the condition of this unity. Take as a concrete illustration of this, the fact that an individual wakes up in the morning and continues to have certain experiences which are recognized as connected with experiences of an earlier period of life. The scientifically recognized unity of the nervous system in such a case as this is inferred from the experienced unity of consciousness, and we say that the nervous system has undoubtedly suffered no serious change in the case of the normal individual, just because there is unity in experience which forbids us to infer any disintegration of the conditions of experience. To think of the concept of a unitary nervous system, after it has derived its unity from the study of experience, as being superior in unity to the conscious self, and as explaining the unity of the self, is simply to invert the course of human thought and to attribute to the derived concept a validity and permanency which is denied to the more immediate concept from which it is derived.

The unity of external objects recognized through a comparison with the self.

There can be no higher justification for the recognition of the unity of the self than that which is derived from the study of experience. Experience shows, in all of its particular examples, that unity is its fundamental characteristic. This unity which is always recognizable in particular experiences is generalized and attributed to the larger succession of experiences. Indeed, the unity of experience is ultimately transferred to physical realities, because the conception of the self and the conception of these physical realities have been built up in the same consciousness, and will, therefore, necessarily have attributes which are congruous with one another. When one comes back time and time again to the same object and recognizes it as familiar and attributes to it a continuity which he has not observed, he is projecting a practical concept into the world of outer realities. When science thinks of the

The largest unities attributed to personality and to physical things are derived concepts.

earth as a unity, or of the universe as a unity, this is a concept, not a percept. The same kind of comprehensive generalization appears in the practical and scientific study of self. It is probably not true that animals recognize their own unity. Experience with them is, as it is with us, a succession of interrelated events, but the survey of the total succession is not possible in the undeveloped animal consciousness. It is probably not true that children have any broad view of the unity of their personalities. The ability to remember is one of the most significant special experiences from which we derive the content with which to construct a broader self. The ultimate recognition of the most comprehensive unity is, however, a conceptual rather than perceptual fact, even after memory has made its full contribution. To demand that the details of the total unity be filled in with a concrete image or illustration is to demand even more than natural science would demand, if it required a direct perceptual representation of its ultimate substances, such as the atoms.

The self is a concept with which no other science deals; it is, therefore, the characteristic subject-matter of psychology.

Scientific psychology is justified in insisting that there is no more definite unity in the world than the unity of experience. To derive the nature of the self from a consideration of matter, through any secondary consideration of other realities which are known only through remoter and more indirect forms of conception, is, as has been stated before, an inversion of the problem. This is unquestionably the largest justification for the statement that the science of psychology has to deal with a concept which is not present in any of the other sciences. Indeed, by every possible device, the other sciences strive to eliminate the self of the scientist. The problem of science as it is defined in the more fully matured natural sciences is, accordingly, so radically different from the problem of psychology that psychology is misunderstood at times and accused of not being a science, because it includes the self. It is true that the center of conceptual construction is different in psychology and the physical sciences; but as systematic efforts to build up complete concepts,

both psychology and the physical sciences have missions which are supplementary to each other, so that they are in the highest accord, rather than in conflict. Natural science strives to build up concepts of objective phenomena; psychology deals with the self which builds up all these concepts. The full definition of this unitary center of experience is the highest development of scientific conception. It differs in its content and in the type of relationships which it includes from every other scientific concept, and it stands in a unique relation to every other scientific concept. Its essential characteristics are its unity and its self-consciousness. These characteristic attributes cannot be further reduced; they may be further elaborated into all of the various possible forms of relation of which experience is capable. The self cannot be eliminated by reference to any of the elements of experience or by reference to the center of physical reality treated in the concepts of physics or chemistry or even of physiology.

The concept of self does not belong to the same class as the concept of matter.

The recognition of the significance of this concept of the self, as a fully justified scientific concept, has been opposed in some quarters by scientists and philosophers, who fail to apprehend its true character. Men who study natural science are often disposed to criticise the concept of the self by canons appropriate to their own studies. They are disposed to demand the reduction of the self to aggregates of molecules or brain cells. The practical sense of humanity stands opposed to this, and the intelligent recognition of the nature of the concept of the self does away with many of the difficulties which have been imagined. The self is, under the view which has been worked out in the foregoing paragraphs, a conceptual construct and not a directly perceivable fact. As a concept it has the same relation to reality that any scientific concept has. It is the ultimate unity which is derived from the examination of all the various forms of organization in experience.

In closing this chapter, it will not be out of place to comment once more upon the curious tendency in

The self a valid scientific concept.

much modern thought to deny any primary reality to the self. Much recent psychology has been timid about the use of any word which would imply an underlying reality, other than the brain, back of experience. Experience has been used to formulate a system of concepts of matter and external realities, but experience itself, because it could not easily find a place among its own constructs, has been ruled out of the world of science. Our considerations have led us along strictly empirical paths to the recognition of the self as a fundamental concept, necessary in the intelligent explanation of life and man's place in the world. The nature of the concept of the self, as we have learned to know it through scientific analysis, should relieve us of the necessity of any defense of our study and our science. In order that our position may be unmistakably clear, let it be asserted concisely that the scientific study of conscious experience leads to a concept of unity and self-consciousness, which is the most fundamental and comprehensive concept which can be formulated in experience.

CHAPTER XIII

IMPULSE AND VOLUNTARY CHOICE

Historical significance of the problem of the nature of voluntary choice.

One of the problems which arises in scientific psychology, and which requires special consideration, is the problem of the nature of activity, whether it is of the simpler impulsive type or of the complex type seen in voluntary choice. The answers given to the questions which arise in the course of this discussion bear not only upon science, but also upon practical life and upon our views concerning the nature of ethical conduct and responsibility. Indeed, there are, in the history of psychology, many discussions in which this problem has been the central theme of interest. The careful analysis of the nature of mental processes has often been omitted in order that a solution of the problem of volition might be reached. In these discussions it has frequently been asserted that the individual is free in the selection of his modes of behavior. It has been as stoutly affirmed, on the other hand, that the individual is limited by his own development, and even by external circumstances, in such a way that he cannot be said to be free. The ultimate solution of this problem involves considerations which lie outside the domain of a scientific analysis of activity. Nevertheless, the contribution of scientific analysis cannot be overlooked in any final treatment of the matter.

This discussion is in a measure a review of earlier discussions.

In many of the discussions in earlier chapters, we have touched upon active processes of different degrees of development. The present treatment of impulse and choice, as phases of the active nature of the individual, constitutes an application of many of these earlier discussions, rather than an altogether new treatment. We may regard it, therefore, as our special task in this chapter to bring together all of the facts which are

available with regard to the active side of individual life, with definite reference to the explanation of those highest forms of activity which are known as voluntary choice.

Choice contains involuntary elements and is conditioned by the momentary state of the subject.

It may be well to call attention to two obvious facts which immediately show the complexity of all those activities which we have to consider in this chapter. The first of these facts is that, in the simplest impulsive activities and in the highest forms of voluntary choice, there are elements which can be explained only in terms of complex nervous organization. If, for example, a man moves his hand so as to reach a certain object, the movement of the individual muscles certainly is not related to consciousness. The mechanism of movement is provided in the organization of the central nervous system and the connections of the nervous system with the muscles of the body. The whole process of coördinating the different muscles is, therefore, beyond the range of individual choice or individual knowledge; it is as involuntary in its detailed composition as the movement of the heart and blood vessels. Yet, while the details of the movement of the hand may all of them be said to be the products of a fixed nervous organization, there can be no question that the act, as a whole, is related to the experience of the subject. The second fact showing the complexity of all behavior is that there is no form of behavior unrelated to the general background of nervous and muscular activity which immediately preceded and now accompanies the act under consideration. This may be expressed by saying that there is at no time a complete relaxation of the muscular system and that, consequently, there is no possibility of finding a case of movement in which the activity rises out of complete antecedent relaxation. Every movement is a phase of a composite general bodily activity, the particular movement being nothing but an emphatic point in the total system. This may be illustrated as follows: If, as one sits in his chair, a bright light is suddenly flashed into his eyes from the right-hand side, there is a strong probability that there will be aroused in him

a movement of the eyes and head in the direction of the light. Such a movement may be said to constitute a well-defined response to a single stimulus, though it is in reality made possible as much by the general condition of the subject which preceded the stimulation, as by the stimulus itself. The reactor would not, for example, have looked at the light as readily if he had been drowsily relaxing, or if he had been engaged in watching intently some other object. He would, in either of these cases, receive the stimulation from the bright light, and would experience a faint tendency to react, or some conflict of tendencies, which conflict of tendencies might ultimately be relieved by the ascendency of one group of impressions or the other. In either case, the final attitude and behavior would depend, not merely on the momentary stimulus, but on the total preparation and active condition of the reactor. What is true in such a simple case is even more true of complex activities, in which the conflict and final selection of tendencies are clearer; as, for instance, in all cases of voluntary choice. To speak of a separate act is, accordingly, an extreme abstraction. Any rational understanding of conduct requires that the characteristics of such a single act be related both to the background from which it proceeds and also to the elements which enter into it. It is, however, convenient to make the abstraction, which is involved in considering a separate act as a suitable subject for study. We shall find later, after having considered a number of these separate special acts, that a full explanation of their character requires us to consider the relations which we have neglected for the moment in the abstraction; that is, the full explanation of any single phase of conduct is related to the total background of nervous organization and individual experience. The acceptance of this later type of explanation will be much easier, if it is recognized from the outset that a single act can be selected from the total active side of life only by a process of scientific abstraction.

It will be well for us to enter upon the description and analysis of behavior by taking up first the considera-

Impulsive action is action of a simple type.

tion of certain of the simple forms, known as impulsive movements. These appear when one reacts upon a strong definite stimulus. Impulsive acts are so direct in their character, and rise to such a degree of emphasis above the general tension of the muscular system, that it is easy to concentrate attention upon them and make them subjects of scientific examination. For example, to repeat the illustration used a moment ago, if an animal is stimulated by a bright light or a loud sound, a perfectly definite form of movement generally results, consisting in a turning of the head toward the source of the stimulus. This act is impulsive; a single impression dominates for the moment the nervous organization and sets up an emphatic activity which is so pronounced that all other tendencies are clearly subordinated.

Impulse often depends on inherited nervous organization.

The characteristics of such an impulsive act can be explained only by a consideration of the antecedent developments within the individual, which make the act possible. Very commonly an impulsive activity is the expression of an instinct. An appropriate stimulus finds the individual prepared to react upon it with a vigorous and emphatic mode of behavior, because the nervous system has inherited certain nervous connections which give the stimulus a definite path of discharge. One can say that the absence of choice or volition is here explained by the presence of an inherited structure. We see that the absence of volition, therefore, can be explained only by a reference to the conditions which precede the present momentary act. This general conclusion, that different forms of behavior can be explained only through the consideration of the nervous development which precedes them, can be made still clearer by an analysis of a number of forms of activity, all of which have the characteristics of impulsive behavior, but are of different degrees of directness and simplicity.

Reflex activity.

The most direct form of behavior which appears in an animal's life is that which is known as reflex activity. This depends upon the independent action of certain of the lower centers in the nervous system, and

is probably not accompanied by any high degree of consciousness. When, for example, a human being who is fast asleep makes a movement in response to some stimulus applied to the surface of his body without being aroused to waking consciousness by the act, the whole process may be regarded as one of a reflex type. It has sometimes been argued that such an act is related to a vague form of consciousness. For our purposes it is not necessary to settle this question; it is enough to recognize that there certainly is no high degree of consciousness present; certainly there is no deliberation. The activity is obviously primitive in character and far removed from voluntary choice.

Sensation-reflex.

Above a pure reflex, such as we have been describing, there are all possible grades of impulsive activity. The grade immediately above a pure reflex has sometimes been designated as sensation-reflex. A good illustration of a sensation-reflex is given when the eye winks to protect itself from a threatening danger. Such a movement as that of winking does not involve even a consciousness of spatial relations, which might be involved in an instinctive movement toward the side of the field of vision. We may say of the winking movement that it is purely a protective activity, and that on the conscious side it involves only the most meager consciousness of the sensation, while the movement of the eye toward the right or left brings with it the perceptual recognition of the position of the stimulus.

Perceptual activity.

There are other forms of impulsive activity which are higher than sensation-reflexes, because they are not mere responses to sensations, but to complexes of sensations, or percepts. The muscular activity itself may be no more complex than that aroused in a sensation-reflex, but the organization which precedes the act is more complex; hence, the distinction in the two levels of behavior. The impulsive character of a perceptual activity, as the response to a complex of sensations may be called, is frequently explicable only in terms of long individual development. This individual development, as we have shown in earlier discussions, separates certain phases of experience from

other phases by the processes of perceptual analysis and binds these discriminated phases of experience together in what we have called perceptual fusions. The processes of activity which correspond to these perceptual analyses and fusions reflect the discriminative experiences on which they are based, for the perceptual act is relatively distinct from the total muscular tension of the individual. This discrimination is, however, not a form of choice or deliberation, but is rather the product of a relatively simple type of mental and nervous development.

Perceptual activities have been described in the study of the forms of perception.

There are as many different types of perceptual activity as there are different types of perception. Foundations for the discussion of the different classes of perceptual activity were laid in an earlier chapter. Attention was there called to the fact that the very organization of the percepts is controlled by the active ends toward which the organizations lead. It was also shown in detail that spatial organization and unity in our interpretation of objects, as well as the recognition of time, are all of them different phases of motor organization, as well as sensory organization. It was also pointed out that attention and feeling are related to immediate forms of behavior.

Examples show the dependence of perceptual activity on organization rather than choice.

It may be well to reconsider one of the examples used in the earlier chapter on perception, to illustrate the fact that the movement which is involved in this perceptual process is not a form of choice or volition. If the recognition of a slender column gives one a feeling of strain, which is accompanied on the physical side by some tension of the muscles, this tension of the muscles is not worked out as an expression of individual volition. It is rather the result of a past series of experiences which have been organized into a compact whole. In many experiences of what has been called perceptual sympathy, we do not choose our reactions; we merely become more and more familiar with objects in our environment, and gradually come to accept these objects as matters of course and adjust our behavior to them without being conscious of our adjustments, or without deciding in any voluntary way what

these adjustments shall be. Indeed, one of the reasons why it is so difficult to make a psychological analysis of the processes of perception is found in the fact that the active elements which are directly connected with the perceptual organization are never presented in consciousness as clearly recognized factors.

Perceptual activities are never deliberate.

If one considers all of these forms of impulsive activity, it is obvious that they are, from the point of view of the actor, determined in character by something outside of his present experience. This absence of immediate consciousness of the conditions of the act is the most characteristic fact in impulsive behavior. When, for example, a person is astonished or angry at any given situation, there is a great body of muscular activity following upon the reception of the impressions, and yet these activities are not anticipated in consciousness by the subject. They express the instinctive tendencies of his race or the organized background of his individual experience; they never have even the appearance of being determined by preliminary choice. The relation of perceptual activity to organization is sometimes obscured by the fact that the perceptual act is part of a train of activities and the attributes of the whole train are assigned to each elementary act. Thus when one reaches for an object on his right, the reaching depends for its precision upon organization, not on present choice. The unorganized infant is unable to execute such a perceptual act even if he attempts it.

Attention does not determine action, but is itself dependent on organization.

There is one phase of perceptual activity which has sometimes been described as voluntary. Thus, when one gives attention to an object and directs his action to it, he is said to be voluntarily selecting one fact and voluntarily excluding others. To say that attention is a force capable of making a perceptual selection is to fail to recognize the fact that the selection is in itself an expression of individual organization and dependent upon the individual's past history. If one looks at the matter from the point of view of his momentary experience, not asking at all the question of the origin of attention, but considering attention as the primary

fact, there is apparent justification for the statement that bodily activity always follows in the line of attention. We very commonly say, therefore, in a superficial statement of the case, that attention determines the direction of clear perception and consequent bodily activity. Here is one of the cases where we must take a larger view in order to get a complete scientific explanation of the case. The moment we ask what determines the direction of attention, we see that the psychological problem is essentially the problem of explaining attention, and not the narrower problem of the momentary direction of bodily movement. The direction of attention can be explained only by reference to the individual's organization. We find ourselves, therefore, moving in a circle. Neither attention nor bodily movement can be used to explain the other factor of the situation, because, as we have seen in an earlier chapter, attention is always related to the organization of behavior, and behavior is, as we find in many cases, related in some way to attention. The two must be accounted for by some more ultimate fact of organization, which precedes both. If this more ultimate explanation is neglected, the whole process may take on the appearance of an event without antecedent conditions. The introspection of the ordinary observer carries him no farther back than the first stages of attention, and this seems to him to be an uncaused beginning. He overlooks the fact that the tendencies of his attention are determined by the organization of his whole life. The scientist, on the other hand, must take a more comprehensive view of the processes of attention; he will find unlimited evidence, which goes to show that the individual is not at the beginning of causes when he commences to pay attention, and, consequently, is not justified in attributing his behavior to attention as the sole or adequate cause.

Examples of natural forms of attention.

The scientific evidence which shows that attention is dependent upon organization is very clear. To take a simple case, let us consider the fact that if carnivorous and herbivorous animals are offered the same kind

of food, one type of animal will immediately proceed to take the food and will be thoroughly absorbed in attention to it, while the other will be deterred by natural development from even giving attention to the proffered food. In neither case can we describe the act as due to spontaneous attention. Similarly, it may be said that the great majority of activities in human life involve organizations of long standing which condition behavior, even though we have no introspective evidence of the organic conditions which are involved. Once we are seated at the table, we eat without elaborate conscious choice, because eating is a fully developed perceptual activity consisting in the adjustments of various details of our action to the complex situation, quite apart from any deliberate weighing and balancing of the elements of this situation.

Animal attention shows by its limitation that it is not free.

Another indication of the true relation of attention to organization is found in the fact noted in discussing animal attention; namely, the fact that animals have a relatively limited range of attention. Food and enemies engross their whole life. Could an animal attend to a work of art? Certainly not, unless it mistook it for food or an enemy. The animal is required by its nature to move in a certain round of adjustments. Its present attention and future attention are directly related to the rigidly circumscribed instinctive organizations which mark the limits of its individual adjustments.

Human attention ordinarily not deliberate.

Clear illustrations of the relation of human attention to development are somewhat more difficult to find, because the possibilities of human organization are such, that attention may be directed in a great variety of different channels, and particular facts of development are more difficult to select. It is clear, however, that the ordinary individual does not pay attention to many of the objects about him, because these objects are in no wise related to his organized practical behavior. The type of illustration which may be used to make this clear is that which is frequently cited in descriptions of savage intelligence. The savage, walking through the forest, has his attention drawn to a great variety

of indications of animal life and human life which altogether escape the attention of the ordinary individual. This highly developed recognition of the facts which are significant for the forest dweller is not the result of any momentary present volition, but the expression of a general system of life and activity.

Attention is not an independent factor in determining conduct.

On the basis of the foregoing discussion, it must be recognized that attention is explicable only in terms of development, and that consequently its influence upon behavior must be explained ultimately by reference to the relation of organization to behavior. The testimony of ordinary life must here be superseded exactly as the testimony of ordinary experience is superseded in all of the ultimate explanations in physics and the other sciences. Perceptual attention may seem to be a matter of the moment and a matter of the individual control, but the complete study of its character makes it evident that such attention is not a matter of individual choice.

Conflict of impulses the basis of higher forms of conduct in individuals capable of ideational processes.

Turning from perceptual activity to still higher forms of behavior, we find that these higher forms of behavior grow out of the fact that at any given moment there may be a conflict between the various tendencies toward impulsive behavior. Suppose, for example, that when food is offered to a human being, he is at the same time aware, because of the broader scope of his experience, of the necessity of exercising a certain self-restraint in order to provide for future needs. This idea of providing for the future may be derived from any one of a large number of experiences. As a matter of fact, the idea of future need has been one of the most difficult lessons for man to learn, as we see if we study the behavior of savage tribes. The savage proceeds ordinarily to take food so long as the demand exists within him and the supply exists without. In fact, he is so ill-trained in the management of his food supply, that he commonly eats to excess when supplied with all that he desires, and wastes lavishly what he cannot immediately use. The storing up of food requires an elaborate mental development which shall make it possible to introduce into the present situation,

not merely a perceptual tendency of response to the given food supply, but also a conflict of tendencies which depends upon ideas and leads to the balancing and weighing of possible lines of activity. It is just at this point that a type of experience may arise in a being capable of forming ideas, which can no longer be described by saying merely that one has an impulse to activity. He has, indeed, an impulse to activity, but he has also other impulses which hold the primary impulse in check. It may be doubted whether such a conflict of impulses could lead to a definite form of experience in an individual who does not have the possibilities of ideational activity. There may be at lower levels of mental life a certain conflict between impulses, but this consists merely in an oscillation between one and the other mode of behavior. Thus, as we have shown in an earlier example, the instincts of fear and sociability may work themselves out in the child's life into an intermediate form of behavior through the preponderance of one or the other natural tendency. The conflict in such a case as this is not the source of a voluntary decision. It may become, in a being who is capable of ideational thought processes, the occasion for a voluntary decision, but in the child it is merely an oscillation or a conflict of tendencies.

Deliberation is a substitute for direct trials.

If such a conflict as this arises in the experience of an individual who is capable of the higher forms of ideational activity, he takes the various tendencies of behavior up into a more elaborate sphere of comparison and deliberation. Without acting immediately upon one impulse or the other, he is likely to follow out in a train of ideational processes a consideration of the consequences to which one or the other impulse might lead him. In other words, he makes a tentative experiment within his own consciousness, this tentative experiment being somewhat analogous to the experiment which would be tried in the direct form of trial and error, if the individual were a simpler animal and were driven by one impulse or the other to the natural consequences of that impulse. The ideational con-

sideration of the different modes of behavior thus comes to be a type of adaptation which is superior to mere impulsive activity, because it saves the individual from certain disastrous consequences by allowing him to run through the whole series of activities in thought, rather than in practical experience. There is, in a certain sense of the word, a substitution here of thought processes for activity, and in so far as thought processes can be substituted for activity, deliberation or choice is substituted for impulsive behavior. It is true that it is impossible for an individual to carry on these thought processes without having certain forms of expression. This we have seen in earlier discussions of ideational processes. The tendencies toward expression are, however, of an indirect order. Thus, the thinker may work out the consequences of a certain tendency to action in a merely verbal form, and compare this tendency and its consequences with the tendencies and consequences of some other type of verbally considered action. The process of comparison thus involves a kind of theoretical activity or verbal activity, which in the higher stages of mental life is substituted for direct impulsive trial.

The self as involved in all volition.

Such ideational comparisons of possible courses of behavior can never go forward to any extent without developing certain systems of internal unity and relationships which correspond directly to those internal unities and relationships which have been discussed in Chapter XII as constituting the recognized concept of the self. When a certain impulse to behavior is held in check long enough to be translated into terms of theoretical judgment, it will inevitably come into some relation with the organized system of ideas, which constitutes the self. Suppose, for example, that an individual finds himself in the presence of an opportunity to possess himself of a certain piece of property. There may be conflicting tendencies that, in his thought, lead to various consequences which should be carefully compared with one another. The outcome of such a comparison will be very largely controlled by the total group of interests which he has

built up in his individual life as representing the sum total of his personal relations to the world. If the property in question does not fit into the plans of his individual life, if it tends to disturb the whole development of his personal ambition and personal effort, the tentative consideration of the impulse to take this property will ultimately issue in the suppression of the impulse, because it does not comport with the organized self. Here, again, we find the clearest evidence that a single process of ideational comparison is not explicable as an isolated fact. The truth is that the explanation of volition as a part of self-consciousness can be given only by a recognition of those processes of organization which have entered into the elaborate construction of the concept of the self. When one says that he has decided not to perform a certain act, he has, to be sure, given the highest possible expression of his own self-control, but self-control in this instance cannot be explained without some reference to the origin and development of the self. It may be objected that the explanation here is so complex that it does not throw any great light upon the single performance. In contrast with this complex scientific explanation, the single act of self-restraint seems to stand out, so far as individual experience is concerned, as a very clear and isolated fact. There is no reason, it will be said, in introspective consciousness for any reference to a long train of past history. In answer to these objections, our earlier discussions have prepared us to understand that the individual self is clear and definite in its apparent influence upon the situation, just because it embodies in such a compact form all that has entered through development into the organized nature of the self. There is, therefore, ample justification for a sharp contrast between the attitude of the individual toward his own performance and the attitude of scientific psychology toward the same fact. The individual does not have to go back into his past history; the psychologist must. The individual is not aware of the complexity of the conditions which are involved in the act; the psychologist cannot truly represent the facts

without reference to those complex organizations conditioned by past experience.

After deliberation, the practical movement is of the nature of an impulse.

The disposition to regard voluntary decision as entirely different from the other processes of action can easily be shown to be misleading, when it is recognized that the final active process, which arises after the ideational weighing and balancing of possibilities is completed, is always closely related in its nature to perceptual response. After the individual has compared this and that tendency toward various forms of behavior with one another and with the demands of the self, there will issue a final resultant form of activity which is not theoretical, but practical. If, now, we examine this resultant practical form of behavior, it will be found to be along the lines of individual bodily organization and will fit into the formula which we have adopted for impulsive activity. If, for example, one has an impulse to fly, he may consider this impulse and compare it with what he knows of his individual abilities, and may ultimately reach a certain conclusion. If this conclusion leads him to decide to try to fly, his effort must be brought to the level of direct impulsive activity. When the decision is brought to this level, the theorist is sure to find that he can make only those movements which are provided for by his bodily organization. From his efforts he may gain new experience, which will lead to a revision of his theoretical conclusions, but the fact which we are interested in emphasizing for the moment is, that deliberate behavior must in the last analysis make use of the same organized possibilities as are employed in impulsive activities.

Theoretical conclusions may be free, but only when they are uncritical.

Many of the ideational combinations which we reach are not thus put to the practical test. The conflict of impulses goes forward at the theoretical level, and one reaches certain conclusions without actually putting them into practice. Such theoretical conclusions seem very frequently to be independent of the laws which govern mental processes in general, and of the restraints which surround practical behavior. It is probably true that the common notion regarding the nature of voluntary choice is largely determined by this possibility of

arriving at theoretical conclusions which are never tested. Conclusions can, however, be formed in this wholly independent fashion only by the uncritical mind. For the careful, critical thinker, even theoretical conclusions are by no means independent of clearly recognized organizations in experience. This can be shown very strikingly in certain cases where it is quite impossible for any of us to disregard critical canons of thought and make arbitrary ideational recombinations, because the nature of the ideas is such that their relations are very explicit and they cannot be bound together in any way except that which is recognized as prescribed by developed experience. For example, the simpler mathematical conceptions are so definitely formulated and so clear in their character, that it is quite impossible for us to combine them arbitrarily. One cannot accept the combination, two and two are five, because the nature of the concept two and the nature of the concept five are so clearly defined, that it would obviously require a fundamental reconstruction of these ideas and of all antecedent development to bring them into the relation used in this example. On the other hand, the ordinary individual has no difficulty whatsoever in bringing loosely together certain ideational constructs which are inharmonious when their true characteristics are explicitly brought out. The arbitrary combinations are possible, because constructs are obscure in the mind of the thinker, and the inharmonious elements are uncritically united. Thus, it is quite possible for the ordinary individual to think of a human form supplied with wings which shall be large enough to make flying possible. The student of physiological mechanics, however, as his ideas become more and more thoroughly organized, finds it less and less easy to make arbitrary recombinations of this sort. He speaks of the idea of a flying human figure as a myth, and finds it wholly inacceptable, because the principles of flying are so absolutely incongruous with the structure of human musculature. The thought of a highly trained individual is, accordingly, recognized as very much more

Examples to show the dependence of ideational processes on development.

dependent upon laws of organization for its possibilities of combination, than is the thought of an untrained human being. The scientist is supplied, not merely with general modes of conscious fusion, but he has made these modes of fusion explicit and can consequently trace out the reasons for this thought combination more fully through introspection than can the untrained thinker. It is also true of the adult that he is more completely conscious of the grounds of his ideal combinations than a child. A child shows the superficial character of his development in the looseness of his ideas. He shows the same characteristic in the fact that he will undertake almost any form of behavior in response to a given situation. His ideational system has not been corrected by comparison with the perceptual system, and he rushes impulsively into the execution of any mode of conduct which suggests itself. The child's notion of himself and his limitations, his idea of the external world and its laws, are so immature that he is able to work out, as we have seen in our discussion of the imagination, the most grotesque forms of arbitrary combinations.

Concept of development opposed to concept of caprice.

The tendency, therefore, as development goes forward, is to adjust thought processes to the possibilities of behavior and to the canons of criticism described in the discussion of conceptual thought with ever increasing exactness and with increasing recognition of certain fixed modes of procedure. Here again, we have clear evidence that the processes of development and the processes of conscious choice are intimately related, and we see again the impossibility of explaining thought and conduct, even at this highest level, without direct reference to the total development of the individual. The scientific attitude on such a problem as that of the freedom of the will is clear enough from what has been said in the foregoing paragraphs. The superficial verdict of introspection is not reliable as a basis for the settlement of the question. The concept of mental development must be exhaustively treated before the problem of freedom can be properly taken up. That individual character develops, certainly cannot be denied.

That there are important changes in individual modes of thought and behavior in the course of development, can also not be denied. There is increasing evidence with the growth of science that development follows regular laws. The whole problem rests, therefore, on considerations of a very general type. The final solution of the question of human freedom cannot be given until the principles of development which explain bodily and social life are exhaustively treated. Psychology may very properly treat its contribution to this discussion as, in a certain sense, partial. On the other hand, the student who has made a scientific study of volition can never come back to the superficial view of the uncritical thinker.

Early scientific studies of behavior were external, because they were borrowed.

Before closing this discussion of the forms of behavior, it may be well to refer to the development of the scientific methods of investigating bodily movements. The earliest scientific investigations of bodily activities were undertaken from a wholly external point of view. The specific method which was used for such investigations was devised by the astronomers who were interested in understanding the deficiencies of human movements when attempts were made to use these movements in recording the transit of stars through the field of the telescope. The astronomers found that the hand cannot be moved as soon as the eye sees a light. They therefore measured the interval which elapsed between visual impression and hand movement. They found further that different individuals have different personal equations, or periods of reaction. Evidently, the observations of the astronomers are very suggestive as foundations for psychological investigations. The early psychological investigations, however, did not transform the method into a psychological method; they took it over unmodified. Their investigations of the active processes were not based upon any elaborate analysis. Certain simple movements were measured with reference to the time which elapsed between the stimulus and the muscular contraction, exactly as this time had been measured by the astronomers. The investigation of this time of reaction was

treated as an indirect means of getting at the complexity of the nervous and conscious processes preceding the reaction. It was found, for example, that the length of time required for a simple reaction was appreciably shorter than the length of time required for a reaction which involved the discrimination of two simple colors from each other. Thus, if the reactor were required to move his finger as soon as possible after being stimulated by a flash of light, the measurement of this interval gave what was called a simple reaction time of about $\frac{180}{1000}$ of a second, or 180 σ, the letter σ being used as the symbol for a thousandth of a second. If, on the other hand, the experiment was arranged in such a way that a number of different colors could be presented to the subject, and it was prescribed that he should react only after a clear recognition of one of these colors, then the clear recognition or discrimination added appreciably to the time which elapsed between the giving of the stimulus and the movement, sometimes as much as 60 σ. This longer period of time was known as discrimination time. Again, if, instead of reacting always with the same hand or finger, the reactor was instructed to respond to one kind of stimulation with one movement, and to another kind of stimulation with a second movement, the process involved not merely discrimination, but also a simple choice of the organ to be moved. The reaction time in this case was called choice time.

The external investigations not productive.

The earlier experimenters on reaction were satisfied to seek exact definitions of the lengths of these various kinds of reaction time. They paid little or no attention to introspection on the part of the reactor. The results of a large number of reactions were averaged, and the comparison between different simple mental processes was made in terms of these general averages. The outcome for psychology of these external studies was by no means large. There is very little contribution to the knowledge of human nature in the details of reaction times.

Recent investigations of reactions differ from the earlier external measurements in two respects. First,

Recent investigations lay stress on introspection and analysis of movement.

the effort has been made to find out, as far as possible, what are the conditions in the experience of the reactor during the reaction process. Attention has been called, for example, to the fact that if the reactor's attention is turned toward his hand, rather than toward the organ of sense which is to be stimulated, the time of reaction will for most individuals be shorter. A distinction may therefore be drawn between so-called muscular reactions and sensory reactions. The average difference in time corresponding to this introspective difference is often as great as 100 σ. Again, the different types of discrimination and choice have been introspectively examined. The question of whether the content of consciousness before a choice reaction is an image of the movement to be executed, or a concentration of attention upon the sensation received, has been introspectively studied. The results of these introspective studies have done much to clear up the psychological doctrine of volition. Furthermore, the general outcome of a more careful examination of conscious correlates of reaction has shown how utterly formal was the gross averaging of all kinds of cases in the earlier investigations. It may be said that no introspective differences ever occur without some modification in the duration of the reaction process; hence, differences in duration are highly significant when supported by introspective observation, and should not be eliminated by an arbitrary method of mathematical averaging. The second way in which recent reaction experiments have been elaborated is by analyzing the forms of the reaction movement. It was formerly assumed that the act of lifting the hand from a reaction key was so simple a process that it could be regarded as uniform in character throughout a long series of experiments. Recent investigations show that there is no such thing as an absolutely uniform series of movement processes. There are certain reactors, for example, who, when they make an effort to lift the hand as rapidly as possible, frequently go through a preliminary downward movement before beginning the upward movement. There are other preliminary phases of movement which

Analysis of the form of movement.

prepare the way for the final reaction, and the relation between these preliminary movements and the final movement of the hand may be so complicated as to influence measurably the duration of the reaction period. The relation of these complexities of movement to nervous organization is most intimate. The studies in earlier chapters of the relation of perception and feeling to reaction, have indicated the significance for psychology of the analysis of reactions. By way of criticism of the earlier studies, it may be said that they treated reactions as if they were merely uniform mechanical processes. The recent investigations have made it clear that the study of muscular behavior is productive only when it is related to a complete account of the introspective processes and the antecedent organizations which condition the particular form of movement.

The problem of the explanation of experience, not fundamentally different from the problem of the explanation of behavior.

The study of movement has therefore brought us back to the consideration of principles of organization. Volition and impulse are merely the active correlates of organized forms of ideational and perceptual experience. The earlier studies of mental activity and the present study of behavior are mutually supplementary. We do not require any unique formulas or the recognition of any new factors. Behavior is a necessary and ever present physical correlate of experience, and at the same time a product of all those organizations which lie back of experience itself.

CHAPTER XIV

FORMS OF DISSOCIATION

THE outcome of all of the different lines of study which have been taken up in the foregoing chapters, is that mental life in its different forms is an expression of organization. Whether it be a matter of perception or ideation, of volition or involuntary response to impulses, every form and manifestation of conscious life consists in some kind of organization. This lesson may be reënforced by considering certain states in which the organizations built up under ordinary circumstances give way, and forms of experience arise which must be classified as irregular, or, in extreme cases, as pathological.

All forms of consciousness are types of organization.

Every form of mental pathology or abnormality is in some sense a case of malorganization or disintegration. There are certain mild cases of irregularity which may be classed as forms of maladaptation, rather than distinctly pathological cases. Such are, for example, our geometrical illusions. As we saw in our earlier discussions, an illusion is always an incomplete organization of the sensations presented to the observer. Defects in organization may be carried very much further in the case of a person who has what are known as hallucinations. An individual may, for example, have an irritation upon some part of the skin which, under normal conditions, would be neglected or, at most, treated as an inconvenient excitation of the part; but if the organizations of mental life are unstable because of some general diseased condition of the individual, this excitation in a certain part of the skin may become the center for a most abnormal combination of experiences and may lead to the development of a distinctly abnormal type of interpretation. Every-

Illusions and hallucinations.

thing that suggests itself to the mind may be made subservient to this stimulation, until finally the person constructs an imaginary world, giving the abnormal excitation a value and importance which, in normal life, it could never have had. He may come to believe that he is made of glass or stone, or he may think that some one is attacking him with poisons or acids. These illustrations will serve to make clear what is meant by the statement that abnormal mental experiences are always experiences which result from irregularities in organization, and commonly involve more or less disorganization or dissociation of the elements which should be combined.

Sleep, the influence of drugs, hypnosis, and insanity as forms of disorganization.

We may examine three distinct cases of dissociation in order to make clear in detail what is meant by mental disorganization. First, there is in sleep a form of normal suspension of central nervous activity which has been provided by nature for the purpose of recuperating the individual. This nervous condition is accompanied by a temporary interruption of normal conscious processes. Second, there are certain forms of dissociation and partial reconstruction which are very similar in character to sleep, but do not serve the purposes of recuperation as does normal sleep. The conditions here referred to may be induced by the use of drugs or by certain other devices, conspicuous among which are the methods of inducing hypnosis. Finally, the dissociations and partial reconstructions, which are temporary in hypnosis and after the use of certain drugs, may appear in a great variety of relatively permanent forms in the different types of insanity. One or two of these typical forms of insanity will be referred to later, in order to exemplify the conditions which result from permanent disorganization.

The physiological conditions of sleep.

The physiological conditions which present themselves in the nervous system during sleep are not fully understood, but their general character can be described with sufficient clearness for our purposes. In the first place, the condition of fatigue in the nerve cell has been found to be a condition of somewhat depleted tissue in the cell body. There are also certain chemical

changes resulting from fatigue. These are indicated by the different reactions of fatigued and normal cells to the coloring substances which are used in staining microscopic sections of the tissue. The protoplasm of the fatigued cells, as seen from Fig. 53, is in part exhausted as a result of the processes of stimulation through which they have passed. Sleep must be a condition in which these cells are supplied with nutrition and return to their normal state of energy and activity. During the period of sleep, each cell seems to be capable of insulating itself from the neighboring parts of the nervous system. There are some extreme conditions, probably pathological in character, in which the dendrites of the nerve cells curl up and form, instead of extending branches, little knotty balls across which stimulations cannot easily pass. This curling up of the dendrites is probably a very much more radical change than occurs under the ordinary conditions of sleep. The synapses or interlacing of fibers, which connect a cell with other cells or incoming fibers, are interrupted in most cases, not by any gross movement of the dendrites, but rather by some chemical change in the tissue which makes it difficult for the stimulation to pass across from one cell to another. There are

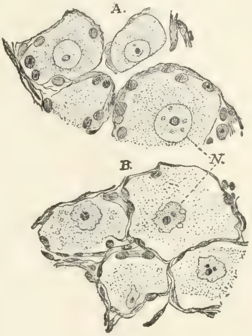

FIG. 53. After Hodge. Two sections *A* and *B* from the first thoracic spinal ganglion of a cat. *B* is from the ganglion which has been electrically stimulated through its nerve for five hours. *A* is from a corresponding resting ganglion. The nuclei *N* of the fatigued cells are seen to take a darker stain and to be very irregular in outline. The general protoplasm of the cell bodies is also less uniform in density in the fatigued cells.

known chemical substances which affect primarily the synapses and prevent stimulations from being transmitted from cell to cell. All of these indications go to show that the nerve cell, when it enters on the process of recuperation, tends to give up its normal trans-

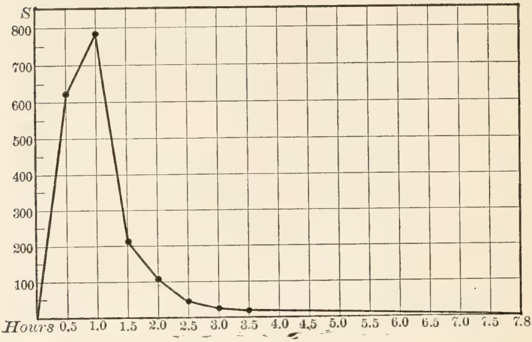

FIG. 54. Curve from Kohlschütter showing the intensity of sound necessary to awaken a sleeper at different periods of sleep. Along the horizontal line are represented the hours of sleep; along the vertical, the relative intensities of sound. Thus, at the end of the first half hour, an intensity of sound somewhat over six hundred is necessary to awaken the sleeper. At the end of two hours the intensity of sound is approximately one hundred. The curve indicates that the sleeper falls rapidly into a profound sleep, and then gradually comes into a condition of very light slumber preceding for a long time the waking.

mitting function, and devotes itself for the time being to the processes of building up tissue.

The sleeper does not receive stimulations.

The external characteristics of a sleeping individual are clearly intelligible in terms of the physiological changes which have been described. In the first place, the individual becomes less and less susceptible to stimulations from the outside world. This means that when any form of external energy acts upon the nervous system, it finds the nervous system relatively

inert. The receiving organs are closed and their cells are probably in a chemical condition unfavorable to any vigorous activity. Even when stimulations are received at the periphery and are transmitted to the central nervous system, they make headway through the tissues with the greatest difficulty. They do not follow the well-defined paths which are used in normal life, but are diffused throughout the whole organ.

Various degrees of dissociation.

The condition of the individual need not be a condition of complete sleep in order to show this inertness of the nervous system. There are many conditions of fatigue in which the nervous system shows before sleep sets in, more or less of a tendency to resist external stimulation. Furthermore, the different stages of sleep are by no means equal in their degree of dissociation. This has been shown by experiments in which the amount of noise necessary to arouse a sleeping individual has been made the measure of the intensity of sleep. The result of such experiments is to show that a person goes to sleep rapidly and profoundly during the early part of the night, and from this time on gradually comes back to a condition of susceptibility to stimulation. Figure 54 shows a sleep curve of the kind which results from these experiments. The curve rises rapidly, indicating, as stated, that the amount of stimulation necessary to arouse the nervous system increases rapidly in the early hours of sleep; it falls off gradually toward the end, indicating a gradual waking of the subject.

Dissociation in the central processes.

Not only are the cells of the sleeper's nervous system impervious to external stimulation, but they are uncoupled in such a way that the stimulations which succeed in entering the nervous system do not follow the ordinary paths of discharge. This uncoupling of the central nerve cells does not take place in equal degree in all parts of the nervous system. The large cells of the spinal cord are able to resist the effects of fatigue, and the spinal cord may be said never to sleep under normal conditions. For this reason, stimulations which reach the spinal cord from the surface of the body are always transformed into reflex impulses and sent to the muscles of the trunk and limbs. The spinal cord is in

this case uncoupled, not within itself, but only with reference to the higher centers. The reflexes are very much simpler in form and more likely to appear under these conditions than when the stimulus has an open path to the higher centers. The medulla, like the cord, seems to be able to resist, to a great extent, the tendencies toward fatigue, for many of the organic processes, such as circulation and respiration, are maintained through the nerve centers in the medulla, while the rest of the nervous system is closed to external stimulation and to any well-ordered activities.

Dreams are dissociated groups of ideas.

One effect of the uncoupling of the various nerve tracts in the organs of the central nervous system above the medulla is that any processes which take place in these higher organs, because of strong stimulations, or because of some abnormal excitability in the nervous system, are fleeting and irregular. The higher centers probably do not all of them sink into the same degree of inactivity even in a normal individual, and the slightest abnormality may result in a heightened activity in certain parts. The facts of consciousness which correspond to these irregular, detached activities in the central nervous system during sleep are easily understood when it is recognized that the nervous system is acting, not as a single organized system, but as a disorganized group of centers. To put the matter in terms of experience, one may say that an idea which presents itself during sleep is not related to the general body of ideas by which the experiences of ordinary life are checked and held under criticism. If, in ordinary life, the idea suggests itself to some individual that he has enormous possessions, he is immediately reminded by the evidences of his senses and by the familiar surroundings and limitations of his sphere of action that the idea is merely a subjective imagination. If, on the other hand, one should have this idea in his dreams, under conditions which would remove it from all restricting relations, it would obviously be compelling in its force and would be accepted by consciousness as an unqualified and unlimited truth. It would be dissociated from the other ideas which fill normal

consciousness, and this dissociation would determine its character in such a way as to make it distinctly different from the processes of coherent thought built up in normal life.

Dreams are impressive only because they are uncriticised.

It will be seen from such considerations as these, that a mature individual is brought in his sleep into a condition somewhat similar to that exhibited in the irregular and unrestrained imaginings of children. The young child, as was pointed out above, constructs imaginations and is quite unable to criticise them because of his lack of experience and because of the lack of organization within his experience. The lines of organization are not laid down in the child; in the dreaming adult, though they have been built up, they are for the time being interrupted, and the processes of mental life lapse into unsystematic and uncritical forms. There is, for this reason, a certain freedom from all kinds of restraint, which makes dreams seem to us free from the limitations of material surroundings.

Motor processes suspended by dissociations in sleep.

The third characteristic of sleep follows naturally from these which we have been discussing. Muscular movements are almost completely suspended in normal sleep. The muscles relax more than they do in any condition of waking life, just because the nervous system does not send any stimulations to the muscles, and, as we have repeatedly seen, the muscles are quite unable to perform their work when they are not stimulated by the nerves. The few struggling stimulations which succeed in getting through the nervous system to the muscles appear in very irregular order and without coördination. The movements which appear are, therefore, irregular and often more incoherent than the fleeting dream experiences which accompany the activities in the central nervous organs. Indeed, in most cases, any intense movements of the muscles during sleep indicate a distinctly abnormal condition and are closely related in character to the irregular coördinations which appear in certain forms of drug poisoning.

The discussion of the phenomena which attend the use of drugs will aid in the understanding of what has

Narcotic drugs dissociative in their effects.

been said about sleep. It is a familiar fact that certain narcotics produce a condition very closely related to sleep. The narcotic drug closes the avenues of sensory reception, reduces central activity or renders its processes irregular and incoherent, and suspends muscular contraction. If the drug is taken in a relatively small dose, so that its effect upon the nervous system is slight, these various effects may be produced in slight degree only. The effect in this case will be most marked in the irregularity of ideas and in the incoördination of the movements.

Effect of alcohol on the nervous system.

A familiar effect of a drug is the intoxication which is produced by alcohol. The chemical condition, and consequently the relations between the various nerve cells, are in some way affected by alcohol, and the stimulations are interrupted or become irregular in their transmission through the tissues. The fact that a man under the influence of alcohol sees things moving irregularly, or sees them double, depends upon the incoördination of the muscles of the eyes. The fact that he is unable to walk steadily shows the incoördination of the muscles of the legs. There is a corresponding irregularity in the flow of his ideas; and his credulousness for the ideas which suggest themselves to him is analogous to the ordinary credulousness of a dreaming sleeper. The imperviousness of such an individual to the stimulations of the outside world is also a well-known fact.

Overexcitation is also dissociative.

In the case of any one of the drugs which produces dissociative conditions in the nervous system, the condition may be overcome by the ordinary processes of recuperation by which the organism throws out the drug. In some cases the effort of the organism to restore the normal condition leads to a reaction which is abnormally intense. We may then have for a time, as a result of reaction to the drug, a state of hypersensitivity and a more vigorous activity within the central nervous system and in the muscles. The dissociating effects of such intense activity in the nervous system may be, so far as consciousness or muscular coördination are concerned, quite as abnormal as the depressing effects

of fatigue or complete suspension of nervous activity. Thus, if the stimulations coming to the central nervous system are much increased in their intensity because the nervous tissue has been thrown into a condition of heightened activity, there may be an irregularity in the central nervous processes due to the abnormally strong currents of excitation and to the impossibility of restraining these currents of stimulation within the ordinary channels of connection and discharge. The disorganization here is like the disorganized behavior of a stream that overflows its banks.

Toxic effects of certain diseases.

There are certain conditions produced in nature which are quite analogous to these conditions produced by drugs. Such conditions appear in fevers when the organism is under the influence of certain toxic substances, and is rendered hypersensitive through the chemical action of these foreign substances on the tissues. The delirium of the fever patient presents clearly the picture of too intense activity in the central nervous system, and the muscular activity of such an individual is directly related to his irregular and excessive central processes. Such a person may also be excessively sensitive to slight sounds or other irritations of the organs of sense.

These negative cases emphasize the relation between normal consciousness and organization.

These different cases show the relation between nervous organization and mental organization, and by their negative characteristics confirm the discussions of the preceding chapters, in which it has been maintained that normal mental life is a continuous process of integration and organization.

Hypnosis is a form of dissociation closely allied to sleep.

The condition known as hypnosis has long been the source of superstitious wonder, and much has been said and written in regard to it which would tend to increase the mystery which attaches to it. In many respects it is a condition closely related to normal sleep. On the other hand, it has certain peculiar characteristics which differentiate it from ordinary sleep. These peculiarities can, however, be fully understood under the formula adopted in explanation of normal sleep, provided that formula is slightly modified to include certain specialized forms of dissociation.

Hypnosis is partial dissociation.

While normal sleep involves the uncoupling or dissociation of the nervous elements, especially of the type which suspends activity in the higher centers, hypnosis involves a dissociation which is partial and leaves a part of the higher centers in action. To put the matter in simple terms, we may say that in normal sleep the cerebrum is dissociated from the lower centers, and various centers in the cerebrum are dissociated from each other; whereas, in hypnosis only a part of the cerebrum is dissociated from the lower centers. The remaining part of the cerebrum continues to carry on its activities, and, indeed, profits by the cessation of activity in the dormant portion, for the active part of the nervous system is, in such a case as this, supplied with an unusually large amount of blood, and its activity reaches a much higher level of intensity, because of this superior nutritive supply and because of the concentration of all of the nervous activity in one region. Such a crude statement as this is undoubtedly too simple in its terms, and yet it represents the situation in principle.

Methods of inducing hypnosis.

The way in which the condition of partial or hypnotic dissociation is produced in the nervous system differs with the practice of different hypnotizers. One of the characteristic methods of producing hypnosis is to require the subject to gaze at some bright object until a kind of partial stupor comes over him. He may then be aroused to activity through the sense of hearing. The ideas which he receives and the activities which he performs have, under these conditions, many of the characteristics of dissociation. Another way of producing hypnosis is to soothe the subject into a sleep-like condition. Stroking the forehead or the face is very commonly practiced by hypnotizers. Here again, the appeal to the subject, after the dormant condition has set in, is through the sense of hearing or even through the sense of vision.

Hypnosis more readily induced after it has once been established in a subject.

When a subject has been frequently hypnotized, it is possible to reproduce the hypnotic condition without elaborate preliminaries. The subject acquires what may be called a habit of dissociation. A simple order

from the hypnotizer is enough to throw the subject into the condition. Sometimes the habit is carried to such an extent that the subject is able to throw himself into the hypnotic condition. Such self-induced hypnosis is known as auto-hypnosis. The ability to produce the hypnotic state in the subject does not depend upon any peculiar powers on the part of the hypnotizer; it depends rather upon his ability so to influence his subject that the condition of partial sleep described shall be induced. The essential condition with which the subject himself must comply, in order to come under the influence of a hypnotizer, is that he concentrate his attention. The only persons who cannot be hypnotized are young children, idiots, and insane persons, all of whom are unable to concentrate attention. This statement effectually disposes of the popular belief that only weak-minded persons can be hypnotized. The most effective method of avoiding hypnosis is to scatter attention as much as possible over a great variety of objects. Concentration of attention is always favorable to hypnosis and allied conditions. The audience which gives close attention to a speaker or performer is susceptible to a species of hypnosis; while on the other hand, there is no danger of hypnosis in a distracted audience. The methods of inducing hypnosis have been accidentally discovered from time to time by performers who are then able to give striking exhibitions of their discovery. Many Oriental jugglers begin their performance, the success of which undoubtedly depends upon their hypnotic influence over their audiences, with a dance in which the body of the performer is moved with a gradually increasing speed, which inevitably induces a gradually increased concentration of attention on the part of the observer. When this dance grows more and more rapid and more and more engaging to the attention, the observer is completely mastered and the main performance may be undertaken. The hypnotic influence of such a dance is very frequently augmented by the burning of incense, which has more or less of a narcotic effect upon the observers. In like manner, certain animals are probably drawn into

a hypnotic state by the movement of snakes. This has frequently been reported in the case of birds and monkeys.

Hypnosis exhibits the two aspects of reduced activities on the one side, and increased activities on the other.

When the hypnotic state has been produced, the phenomena exhibited are of two distinct types. First, there is a suspension of certain activities, and second, there is an abnormal heightening of other activities. This may be seen with reference to the reception of sensory stimulations. Certain stimulations are no longer received by the hypnotized subject. For this reason, the condition has sometimes been used by savage tribes for surgical purposes, exactly as in modern life we use drugs which will produce a dissociation of the nervous system, and thus prevent pain from excessive external stimulation. On the other hand, certain other senses may be open to stimulation. A hypnotized subject may be wholly anæsthetic in his skin, while still retaining the ability to receive impressions through certain of his other senses. Indeed, the concentration of nervous activity in certain particular senses results in such a heightening of their ability to receive impressions that the subject may perform most astonishing feats of sensory receptivity. He may hear very faint sounds or he may see remote visual objects. It is to be noted that this hyperæsthesia of the senses is not so extraordinary as it would at first sight seem to be. We all become hyperæsthetic when we concentrate attention in any direction. If one is listening for an important signal or watching for some object which is of great importance to him, he will be using his nervous energy in the emphasized direction and will be correspondingly impervious to impressions from other sources. The conditions in hypnosis are merely exaggerations of those which appear in ordinary life.

Ideas are not subjected to criticism in hypnosis.

Turning from the sensory processes to the central processes, we find again that certain activities are entirely in abeyance, while others are much intensified. If, for example, it is suggested to an hypnotized subject that he is an animal instead of a human being, the suggested idea may take such large possession of him as to command his whole attention and guide his ac-

tivity. If a normal individual is told that he is an animal, he immediately brings to bear upon the suggested idea a great variety of incompatible experiences, which make it clear that the statement is false and unacceptable. In the case of the hypnotized subject, very much as in the case of the dreamer, the corrective ideas, which constitute the fabric of normal life, are absent, so that the single idea takes possession quite unrestrained and commands belief as the accepted content of consciousness. This credulousness of the hypnotic consciousness is described by saying that the subject is very open to suggestion. Anything that is said to him will be accepted, and any form of interpretation of experience which is offered to him will be taken up without serious question and without any effort on his part to criticise the ideas which have been given him by the hypnotizer. Suggestibility has very frequently been emphasized to the exclusion of the converse fact that the hypnotized subject is quite incapable of subjecting any ideas to critical comparison. So also the positive increase in sensitivity has been the impressive fact; the diminution of sensibility has often been overlooked. The negative considerations are, however, essential to a complete understanding of the case, just as the negative considerations are of importance if we would understand the credulousness exhibited in dreams.

Dual personalities in hypnosis.

The central nervous conditions which are induced in hypnosis are sometimes sufficiently unstable to produce the most complex phenomena. It is sometimes found that the dissociated parts of the cerebrum are not only dissociated from each other, but they are also, to a certain extent, capable of independent action. Thus, while one part of the cerebrum seems to be dealing with impressions received through the sense of hearing, another part may be engaged in responding to tactual impressions. Or, the case may be rendered even more complicated by the fact that the impressions coming from one ear seem to serve as stimulations for certain activities, while auditory impressions received on the opposite side of the body are effective in producing

an entirely different set of experiences and responses. There result in such cases what are known as dual and multiple personalities. By personality, as the term is used in such cases, is meant any organized group or system of ideas and activities. The various groups of systematized activities and ideas which exist side by side in an hypnotized subject, owe their separation to nervous and mental dissociation; each personality is, therefore, a relatively less complex system than that which exists when the whole cerebrum is acting as a single organ. The division of an individual into a number of systems of organization appears in other states than the hypnotic state, and it may result in certain permanent or certain temporary disruptions of personality, which have been noted in such stories as that of Dr. Jekyll and Mr. Hyde.

Dual personalities in other than hypnotic conditions.

From time to time one reads of a case of lapse in memory which amounts to a dissociation of personality. A man forgets who he is or what business he has been following. He is sufficiently normal in his general organization to respond to a great variety of impressions in a regular fashion, but the complex structure of mental life breaks down and the man is only partly reconstructed in the second self. Tertiary and quarternary personalities may appear in all possible combinations. The secondary or tertiary personality may know its fellows, but may be itself quite forgotten. Several cases have been described, in which personality *B* knows not only its own acts and emotions, but also the acts and emotions of the other personality *A*. Sometimes *B* not only knows but heartily dislikes *A*. Sometimes two personalities exist simultaneously within the same body and seem to have separate lives and characters. The writer knew of a case of a young man who was the object of superstitious wonder in the village in which he lived, because he had two personalities. These two personalities knew each other and held long discussions with each other. Often, when they came to a turn in the road, they disagreed with each other as to the direction in which their body should move, and the passer-by

could see the abnormal man mumbling an argument between his two selves.

Dual and multiple personalities analogous to the various selves of normal life.

The details of such cases are baffling in the extreme, but nothing can be clearer from our earlier studies than the general formula of dissociation, with the added fact of partial organization around different centers. The matter becomes more intelligible if we remember that even in ordinary life there is a subdivision of experience into different systems. This matter was referred to in an earlier chapter when we distinguished between the business self, the social self, and so on. Each one of these selves is only partially related to the other systems of experience and forms of behavior. The man who is buried in the details of a business transaction is just as oblivious to considerations of a literary sort as the hypnotized subject is oblivious to a certain group of possible experiences. We do not call the ordinary absorption of the self in business a case of multiple personality, because the neglected personality in the case of the business man is not so remote but that it can be immediately called out, if he turns his attention to some literary considerations. The normal individual is capable of transferring his attention and interest from center to center according as the external environment demands, while the hypnotized subject or abnormal person is, through dissociation, quite incapable of a rapid transfer of attention or of correlating the different phases of his experience.

Hypnosis a transient condition, insanity permanent.

We shall return to the discussion of multiple personality under the general head of insanity, for the fundamental distinction between insanity and hypnosis is to be found in the degree of permanency which is attained in the latter state, as contrasted with the more transient character of the hypnotic condition.

Movements may be normal in hypnosis, because the lower centers are not dissociated.

In the meantime, it is necessary to add a few comments on the motor activities of hypnotized subjects. These motor activities frequently exhibit little or no departure from the ordinary coördinations of normal life. The hypnotized subject is capable of walking, often of writing or producing certain other complex forms of movement. Such continuation of the bodily

coördinations is explicable on the ground that the lower centers of the nervous system are not dissociated by the changes that take place in the higher centers. Whenever the higher centers are able to send stimulations to the lower centers, these lower centers are capable of responding with their usual degree of coördination. The lack of organization is exhibited rather in the inability to maintain a normal balance between the various centers which call the lower centers into play. It is to be noted, however, that the movements of hypnotized subjects sometimes indicate by their clumsiness and lack of precision that the disintegrating force has affected certain of the motor channels as well as the central organizations.

The after-effects of hypnosis tend to become permanent.

There is one group of facts in hypnosis which should perhaps be made the subject of special comments. The suggestions received by the hypnotized subject may, in some cases, be carried over so as to become operative in a later period, after the subject has apparently recovered from the hypnotic trance. Such after-effects are known as post-hypnotic effects, and the suggestions are described as post-hypnotic suggestions. Even more significant is the fact that after-effects of the hypnotic trance are of a general kind. It is a fact that the effect of the hypnotic state is in the direction of a perpetuation of dissociative tendencies. Sleep is transient and leads to a more vigorous form of activity after it is over. Hypnosis, on the other hand, tends not to restore the nervous system to a more vigorous condition, but to perpetuate dissociation. This is due to the fact that sleep is negative, while hypnosis is positive in certain of its phases, in that it trains certain centers to act without reference to others. It therefore operates by virtue of its positive phases toward permanent disorganization. It is for such reasons as these that the use of hypnosis is in general to be avoided. The disorganizing effects of hypnosis are of the same general type as the disrupting tendencies of certain drugs. The individual, who with sufficient frequency comes under the influence of these drugs or of hypnosis, will ultimately settle into a state of

nervous disorganization from which it will be quite impossible for him to recover, even when recovery is demanded for the purposes of normal life. Hypnosis is not utilized by reputable practitioners, because its ultimate effects are not as readily controllable as are the effects even of the narcotic drugs; and there is no justification whatever for the use of hypnosis as a means of amusement, any more than there would be for using a strong narcotic drug to bring an individual into a condition which would make him the subject of observation for purposes of entertainment.

Insanity is a permanent form of disorganization, introduced in many cases by dissociation and settling into an abnormal reorganization.

As has been indicated in the earlier paragraphs, insanity is a form of relatively permanent dissociation. Certain forms of delirium, which have been referred to before, furnish the best introduction to the study of insanity. In delirium the subject is so highly excitable that the normal avenues of stimulation and discharge are for the time being completely disrupted, and the currents of nervous activity and the corresponding facts of experience are dissociated. As delirium disappears and gives place to the usual intensity of nervous activity, the individual may return to the earlier normal condition or, on the other hand, there may be left behind a permanent abnormal state, because the earlier forms of organization are not fully restored. One of the most characteristic symptoms of all forms of insanity is found to be the existence of certain hallucinations or fundamental abnormalities in the subject's world of ideas. The insane person believes himself to be Julius Cæsar or some biblical character, or even some divinity. There is no difficulty in recognizing the fact that the idea of transferred identity may come into the mind of any normal individual. It is, however, in the case of a normal individual immediately criticised and abandoned, because of its incompatibility with the person's general knowledge of the world and his place in it. When the compact organization which has been built up in normal experiences has once given way, and the idea that one is Julius Cæsar or some other character has presented itself as a center of reconstruction in the midst of the resulting

chaos, there is a possibility of an abnormal reorganization of experience. The individual is no longer restrained by that system of ideas which has been laboriously built up through contact with the world; the result is that the whole later ideational life of the individual loses its adaptation to the real world. The characteristic fact in certain cases of insanity is, accordingly, not describable in simple terms of dissociation; it is rather to be defined in terms of dissociation with an abnormal association or integration following upon the breaking down of the normal system. In other cases, disintegration is the more obvious fact. The individual simply loses control of his ideas and his mind seems to be flooded with an incoherent mass of experience. His words reflect this incoherency of ideas and his behavior indicates an absence of self-control. Such disintegrated forms of consciousness and behavior commonly appear in the last stages of almost every kind of insanity, even where there has been for a time reorganization about an abnormal center.

Melancholia as a typical form of dissociation.

One of the very general forms of dissociative abnormality is that which appears in so-called melancholia. In melancholia there is a general reduction of all the bodily activities, including the activities in the nervous system. The subject becomes phlegmatic and depressed in all his functions. The whole feeling tone of experience takes on a marked disagreeable character, which can be explained in terms of our earlier discussion of feeling by saying that the individual does not arouse himself easily to respond to any form of stimulation, and when his nervous system is in any way aroused by powerful external excitation, the reaction upon the stimulus is so laborious and contrary to his tendencies and mood that he has a strong feeling tone of a disagreeable type. The ideas which such a subject has are often organized about each other in a way that furnishes a kind of false explanation of the subject's mood. The melancholic subject has certain grievances against the world. Sometimes these grievances are of a trivial character and make it clear that the grievance could not have been the exciting cause

of the subject's condition. Sometimes the grievance is more real and furnishes an apparent ground for the condition. Even in such a case, it is to be said that the person's physical condition must have developed into one of general debility before the apparent cause of his mental conditions could have become the source of abnormal melancholia. The distinction between a passing case of depression in normal life and melancholia is that passing depression is temporary, and nature rebounds from it in such a way as to produce normal conditions after the depressing circumstances are past. In the case of melancholia, the depressing tendencies become permanent, and it is this permanency rather than the fact of depression or its corresponding nervous conditions which constitutes the characteristic fact in insanity. Indeed, one can find almost every possible grade of transition from normal life to extreme abnormality. The result is that those who have made a special study of these transitions, and those whose attention is for the first time called to the possibility of such transition, are likely to indulge in the extravagant statement that all persons are at times or on certain subjects more or less insane. It is undoubtedly true that all persons do depart at times from the type of mental and bodily organization which constitutes normal life, but unless these states become fixed and lead to distorted and unadapted forms of behavior, they should not be classified as cases of insanity.

Excessive excitation as a second typical case of insanity.

The opposite tendency to the melancholic condition just described appears in certain cases of excessive excitation. A person when abnormally excited is very frequently possessed of excessive bodily strength. This is not due to any change in the structure of his muscles, but rather to the fact that the nervous system which is in control of the muscles is sending to the active organs stimulations of excessive intensity. There are numerous cases in normal life which will help us to understand this fact. If an individual is fatigued, encouragement and stimulation from the outside world will appreciably increase his ability to execute muscular

movements. In the same way an individual may be so stimulated by abnormal substances in the blood, that his whole nervous behavior is raised to a high level of activity and the motor discharges are abnormally intense. The muscular activity of such a person is typical of his whole condition. His ideas come in an overwhelming flood and lead him into the most extravagant excesses of imagination and lack of self-control.

Relation of psychiatry to psychology.

These illustrations must suffice for our present purposes. There are all possible combinations of disintegration and reorganization exhibited in insanity. There is a science known as psychiatry which deals with these forms of dissociation and abnormal association, and there is a large field of practical observation and study open here to the trained scientist. The chief lesson for our general science is that the normal processes are processes of integration leading to forms of association which contribute to adaptation. There are frequently illustrations which throw light upon important principles of normal association, to be found by making a careful study of the facts of dissociation, but in general the explanation of abnormal states is made easier by a careful examination of normal processes, rather than the reverse. It does not follow that dissociation will be along the same lines as association, and the effort to work out the details of one by the other often leads to fallacies. The general tendency of normal life is, however, obviously in the direction of adaptive organization; the tendency of sleep, hypnosis, and insanity, on the other hand, is in the opposite direction. The particular path followed in each case can be defined only through empirical examination of the case.

CHAPTER XV

THE APPLICATIONS OF PSYCHOLOGY

Practical adaptation goes before theoretical explanation.

THE application of psychology to the explanation of various forms of human activity is not always an easy task. Many of these forms of activity have reached a stage of refinement and perfection which, in practical adaptation to the demands of human life, far exceeds our abstract knowledge of the relation of man to his environment, either physical or social. For example, we are all of us capable of adjusting ourselves to the demands of the situation when it is necessary for us to balance ourselves upon any unsteady or narrow footing, and yet the mechanism by which we keep our balance is so complex that the abstract description of the activities involved would require a long and elaborate treatise. Again, long before any individual begins to make a study of the nature of language, he has developed a degree of facility in this mode of communication which makes it, as we have seen in our earlier discussion, one of the most important features of human life. This perfection of practical adaptation prior to the development of theoretical science has resulted in the production of a variety of social institutions and individual forms of thought and feeling which can continue, and do continue, even though it is quite impossible to give a full scientific account of their nature.

Art products especially pure cases of subjective activity.

Among the elaborate productions of the human mind which surpass immeasurably our scientific knowledge are those productions which constitute art in all of its different phases. The sphere of human activity to which we refer when we use the term art is a sphere in which the relations of the individual to his external environment are relatively free. One can paint a picture and suffer no serious inconvenience from its

lack of conformity to the requirements of the external environment. Indeed, the requirements which control the development of this form of activity are not imposed from without, but are imposed rather by the laws of human nature and its internal development. All this is expressed in the statement that art appeals directly to subjective attitudes and does not attempt to deal primarily with external conditions. It is for this reason that psychology draws many of its best illustrations from the sphere of art. If we find a general principle running through art, we are led at once to the conclusion that there is a corresponding tendency in human nature. Certain simple illustrations may be offered. Thus, there is a certain proportion between the long and short sides of rectangular figures, which seems to be generally acceptable. The proportion can be expressed mathematically by saying that the long side is to the short side as the sum of both is to the long side. If we examine those objects which have been freely constructed without special external limitations, we shall find that a great many of them take on this proportion. For example, when an extensive series of measurements was made of the two legs of ornamental crosses, these crosses being purely ornamental in motive and not determined in figure by any requirements of the material used in constructing them, it was found that they maintain the proportion described. This fact can have no objective explanation and must have been dictated by human subjective attitudes.

Symmetry a subjective demand.

Again, most of the forms of balance and symmetry in architecture, painting, and other forms of art, are efforts to meet the demands of human nature, rather than of external requirements. As we have seen in an earlier discussion, the reason why a well-balanced figure is beautiful is probably to be found in the organization of human activity, and the demand for symmetry is so deep-seated that man has always endeavored to satisfy it. If we examine the forms of architecture which grew up in a period when men were free, so far as the external environment was concerned, to construct

buildings of any size which they pleased, rather than to fit their constructions to the requirements of a city building lot, we find that the size and form of these free buildings assumed certain general proportions which were determined, not by the external conditions, but rather by the demands of taste. Indeed, one of the fundamental distinctions between ancient and modern architecture is a distinction which can be described by saying that the early builders followed their sense of proportion, while modern builders follow certain definite laws of mechanical construction. A Gothic cathedral of the pure type very commonly exhibits certain irregularities in the position and size of its columns, which yield in the mass an impression of solidity and symmetry that could not be obtained if every part of the building had been conformed to exact mechanical rules. A modern building is constructed with definite reference to mathematical regularity of dimensions and with reference also to the strain which is to be placed upon every given part of its floors and walls. There is little tendency to use the material freely; there is much greater tendency to do only what is necessary to meet the simpler mechanical requirements. A column made of steel is designed to support a certain weight, and the size of the column used in a building is usually determined by the weight which it is to carry, rather than by its appearance. These facts go to show how the practical demands of his physical environment have bound the activities of man more and more closely to definite adaptations and left him less and less free to express the tendencies of his own nature.

Architectural harmony analogous to musical rhythm and harmony.

There are many indications in the earlier, freer architecture of the Greeks that they followed certain broad principles of rhythmical proportion which correspond so closely to what we found to be the principles of musical rhythm and harmony, that there is a suggestion of a common type of human organization lying back of both spheres of art. It has been pointed out, for example, that the height of a Greek column is an exact multiple of its diameter. Furthermore, the space

between the columns always stands in definite relation to the diameter of the column. In details of construction also, as, for example, in the various portions of the decorations in the Ionic capital, the parts are related to each other in definite unit ratios, so that a constructive symmetry runs through the whole and gives the observer a feeling of composure and unity which needs no theoretical definition to make it impressive.

Literature as an expression of human nature.

What is true of architecture is much more obvious with reference to literary art. Here the attainments of writers have long outstripped our theoretical knowledge of the ways in which literature may be produced. It is clear that the laws of literary composition must be laws of human nature, and the great artists have unquestionably followed with sufficient closeness the demands of human nature to leave their works as standards for future development and as expressions of the direction in which all individual development must tend.

Prose rhythms show the tendency of writers to express an inner law.

Some purely formal indications of the completeness with which great literature conforms to the demands of human nature may be found in the fact that there are even in prose compositions certain typical rhythms which give to these compositions a regular symmetry of character, which undoubtedly constitutes one of its charms. It is a striking example of the fact that art may outstrip science, that it is not yet possible to give any complete theoretical account of the prose rhythms of the best writers. Evidently those who have contributed the great works to literature have succeeded in utilizing the language in which they wrote in such a way as to express an internal organization of their own which was altogether appropriate to their theme and to the vernacular, and this they have done spontaneously and very often without complete theoretical recognition of what they were doing. When the student of such prose arrives by laborious analysis at some knowledge of the rhythms which it contains, he is not creating rhythms, but rather rediscovering by the tardy methods of scientific analysis a formula which has been achieved by the great writer through direct development.

If the forms of prose composition have exhibited complexity of structure, together with a fundamental regularity of form, it is even more true of verse that its masters have never followed rigid mechanical principles in their work. And yet they have adequately met the demands of human nature. Their conformity to a limited group of principles is seen in their adherence to certain regular forms which are sufficiently obvious to be imitated in gross outline by writers of less taste and power; but the full and effective use of verse forms has always involved a certain freedom of manipulation which has defied any complete theoretical account and which certainly has never been directly deducible from what we know of the general principles of psychology. Psychology must frankly admit in such a case as this that it follows in the steps of a complete adaptation, very far behind the adaptation itself. Nevertheless, the psychological problem is clear, and a general suggestion as to the explanation of these facts may be found in what has been said in an earlier connection regarding the nature of rhythm.

Verse another example of the same type.

The purely personal characteristics of a given writer are the characteristics which can be most readily discovered through comparative study. For this reason the usual forms of literary study deal with the personal characteristics of writers, rather than with the fundamental laws of mental nature involved. That there are fundamental laws appears at every step where a general scientific investigation is made, and there certainly is no ultimate reason why the scientific inquiry should not be extended in every direction. In the meantime, even the personal usages of single writers challenge our efforts at explanation. Thus, when it is found that a certain writer has injected at a certain point a figure of speech or a simile, or has abbreviated his expression by deliberately omitting some word or phrase which should naturally have been expected, we can often say why the effect which is produced by the figure or by the striking departure from regular usage is more in conformity with the demands of mental organization than would be the set form of discourse.

The extension of psychological explanations of literary usages is possible and desirable.

The effort to give a scientific explanation at these points is not opposed to descriptive study, which doubtless is entirely legitimate. On the other hand, a descriptive study supplemented by some psychological analysis of the literary device would tend to raise literary criticism to the level of an explanatory science. It is not at all asserted that the explanatory principles thus developed would make it possible for any one to create great literature; but just as geology teaches us more of the nature of volcanoes than does mere description, so the psychological consideration of literary forms would carry us further than mere enumeration of the forms of expression which appear in the great masterpieces.

The significance of intuitions.

There is much justification in such considerations as the foregoing for the belief that scientific and theoretical knowledge is not by any means the only high form of human experience. Indeed, it has often been suggested that human intuitions and vague feelings frequently bring us much nearer to that which afterward proves to be the truth than do our most elaborate processes of reasoning. The poet has always claimed for himself a higher position than he would allow to the scientist who is bound by the demands of rigid evidence. We often speak of the insights of the artist, and mean by this phrase that the artist sees beyond the ordinary facts of definite observation and clear vision to ranges of facts which are of importance, but are not open to our inspection. What has been said in an earlier chapter with regard to the nature of feelings will be of some assistance in clearing up the paradox which here appears. When explaining the feelings, we discovered that whatever runs counter to the organized nature of the individual will arouse a disagreeable feeling. Whatever is in fundamental agreement with nature will give pleasure. If now the experiences of life are in subtle agreement or disagreement with the

Feeling and intuition.

organization of the individual, it does not follow that the individual will become clearly conscious of this fact in ideational or abstract terms, and yet he may be vividly aware of the disagreeable feeling imposed upon

him by a certain experience. For example, as we have seen in earlier discussions, the organization of an animal may be such that certain color stimulations are fundamentally opposed to its natural organization. Feeling is, therefore, a kind of spontaneous adjustment with a practical value which often surpasses that of theoretical judgments. It may be relied upon in those situations where the organization is simple enough or the response direct enough to give an unbiased reflection of the individual's relation to the impression. On the other hand, when life becomes complex, as it is in human beings, native instincts and native feelings are often overlaid by a series of developments so indirect that there comes to be a certain rivalry between the authority of feeling and the authority of abstract knowledge. There can be no doubt, for example, that the social selections by which one determines who shall be his friends are dependent in large measure on intuitions, but one does not need to be very old or worldly-wise to recognize that the complexities of social life are such that the instinctive feelings which we have in making the acquaintance of new individuals are not always safe guides in the development of social relations. What is true of social relations is true, undoubtedly, of artistic intuitions and of larger intuitions of universal truth. It is quite impossible to persuade one who regards a line of poetry as beautiful that it is not beautiful because it violates some rigid law of versification. It is quite impossible to convince one who enjoys a certain picture that the picture is deficient because it does not comply with certain canons of a certain school of art. On the other hand, it is frequently possible, by a series of educative contacts with better artistic and literary forms, to gradually modify an individual's organized feelings so that he shall completely change the character of his judgment. Intuition is, therefore, not a separate and distinct faculty of life; it is rather an expression of that immediate form of recognition of congruity or incongruity which characterizes the feelings as distinguished from abstract theoretical knowledge. The devotee of feeling need

not be disturbed at all by the proposition that literary and artistic forms should be studied and explained. The feeling need not lose any of its value by being examined and rationally explained. On the other hand, no feeling will ever be an ultimate form of experience so long as man finds it possible to superimpose on direct forms of apprehension and reaction, higher forms of abstract thought.

Many of the social sciences have been objective in their methods.

When we turn from the discussion of art and feeling to certain more practical spheres of investigation involving human nature, namely, those taken up in the social sciences and anthropology, we find that the study of psychology is very direct in its application to these spheres of study and explanation. It has not always been fully recognized that psychology has a relation to the social sciences. Certain schools of social scientists have treated the institutions which they study merely as objective facts. To show this, we may take as an illustration one of the oldest of social sciences; namely, the science which deals with language. Language is a product of human activity which has a sufficiently independent existence to make it an easy subject for examination and analysis. To trace the history of a word is to undertake an investigation which calls for little reference to the individuals who may have made use of this word. In like fashion, the study of a system of sounds and written symbols may result in the discovery of certain regularities and laws of phonetics without reference to the human beings who used this language and who were the ultimate sources of regularities in the language itself. The same historical and objective methods have been applied to the study of other institutions. For example, religious systems have been described and their uniformities and divergencies have been ascertained without more than a passing reference to the individuals who developed these systems or adhered to them.

Introspective psychology gives little support to social science.

The tendency to confine attention to an objective study of human institutions has been strengthened by the attitude which for a long time prevailed in psychology, when the chief method of investigation was

the introspective method, according to which the individual attempted to discover the laws of mental life through an examination of his own immediate experience, and with very little reference to the modifying influence of his fellow-beings or the secondary factors of his environment. When the problem of psychology is more broadly conceived, so that it is seen that the character of human mental life can be defined only by a more elaborate study of numerous examples and external relations, the spheres of institutional study and of psychological investigation are gradually brought nearer to each other.

The interrelation of psychology and social science can be made plain.

In the course of recent psychological study, much valuable illustrative material has been borrowed from the sciences which deal with language, and from anthropology. Psychology has thus expanded under the influence of the new body of material which has been adopted into it. The methods of psychology have become more objective and the results of individual introspection have been broadened. On the other hand, the scientific study of all other human beings must be based upon one's own personal experiences. One naturally thinks of primitive man in terms of his own mental experiences. If there is no scientific study of the matter, the student is likely to carry over immature analogies and apply them to cases where they do not illustrate, but rather obscure the truth. Thus, as has been pointed out by a recent writer, there is a widespread tendency to describe the mental abilities of savages by means of a succession of negatives. They do not count, they do not have a full series of color terms, they do not paint pictures, or write. All these negatives are mere expressions of the natural tendency to accept ourselves as standards. We should become sufficiently impersonal in our studies to recognize that savages probably have a nicety of space perception which is very much greater than ours. They may not select color qualities and name them, but for the finer grades of variation in plant and animal life as indicated by color they have the most highly developed discrimination. Not only the savage, but even our con-

temporaries in different civilizations from our own, are exceedingly baffling unless we make some study of their types of mental development. The institutions of Tibet, China, and Japan are obviously different from our own, but the character of the mental processes back of these institutions has been little thought of and little studied. The careful scientific study of the mental characteristics of different peoples is one of the most promising lines of extension of psychological study.

The characteristic changes in human nature as it develops are not describable in any except psychological terms.

So intimately is the institution bound up with the mental development of the individual that we are justified in the statement that psychology is the basis of any explanatory account of social institutions. There is one particular anthropological problem where the significance of psychological analysis can be made very clear. Anthropology has never succeeded in finding structural modifications in the human body which would at all adequately account for the great superiority of highly developed races over the more primitive tribes of mankind. Even the explanation of the crucial development by which man became differentiated from the animals is one of the obscure parts of anthropology. It cannot be denied that the explanation of all these matters must be sought in terms which refer to the development of intelligence, especially the development of language and the use of tools, as has been indicated in an earlier discussion. The problem of anthropology is thus distinguished from the purely biological problem, where intelligence is not recognized as playing any part. How could a certain group of animals suddenly break away from the established type of evolution in which changes in structures played a large part, and become animals characterized by intelligence, meeting the emergencies of their lives by a mental adaptation of themselves, rather than by a purely physical adaptation? Why should this group of animals turn to the development of all the instruments of civilization? The problem stated in this form becomes a problem of functional development, rather than a problem of physical development. This animal must have been driven at some time into a situation where

his development turned upon his ability to adopt a new type of behavior and a new mode of life. There can be no doubt that the scientific explanation of the breach between man and the animals depends upon the recognition of a transformation in the mode of behavior and mental life, rather than upon any fact of gross bodily change. Put in another way, the statement may be made that we need no animal form to serve as a connecting link between man and the animals. The common structure, the common physical needs of man and the animals, are now made out so fully that what science requires is an explanation of the gap, rather than the link, between man and the animals. The doctrine of biological evolution has successfully established the principle of continuity. It remains for genetic psychology to explain the discontinuity which appears when intelligence begins to dominate, when sensory-motor adjustments of the reflex and instinctive type give place to habit acquired through individual intelligence and to the more elaborate forms of thought.

Human development is dependent upon intelligence.

An interesting hypothesis has been suggested by a recent writer which will illustrate the possibility of assuming a distinctly functional attitude toward the question of the development of man. This writer holds that the gradual changes in physical organization which characterize all of the different species of primates, lead up to the development of man only because at one time a number of these primates were forced, probably by the emergencies of a glacial climate in certain quarters in which they were confined, to adopt a mode of life which brought them down out of the trees and forced upon them certain types of activity which led to their construction of artificial shelters and to the preparation of forms of food which had not been previously utilized by their race. The change here assumed depends on the rise of a powerful motive for action in new ways in response to pressing forms of sensory stimulation. Whatever change there was in the individual consisted in the opening of new paths in the central nervous system. This change in the type of development, when once it appeared, was so

An hypothesis to explain the break between man and the animals.

important, that the further history of the group of animals which succeeded in effecting it was in the direction of adaptation through intelligence and nervous organization, rather than through gross changes in bodily structures. Whether we give any credence to this hypothesis or not, it expresses admirably the functional attitude in the explanation of human development. It expresses clearly the fact that the nature of mental and functional adaptation is the significant problem for anthropology, rather than the mere search for changes in physical organization; it gives to anthropology a definite impetus in the direction of the study of mental organization, as distinguished from the study of external somatic structures or of institutions taken up in a purely historical and objective way.

Spencer's application of psychology to sociology.

Another illustration from a later period of human development which will also emphasize the significance of psychological study for anthropology, is to be found in Spencer's discussions, in which he calls attention to the fact that the growth of civilization depends upon the broadening of the individual's mental horizon. He points out the fact that the savage who had interest in only a small range of territory and the present enjoyment of objects immediately about him, gradually developed into the semicivilized man interested in a larger territory, a larger number of individuals, and a longer period of time. The mental development which made it possible for a people to foresee future needs with sufficient vividness to plant crops and build permanent dwellings, was an achievement conditioned upon the development of mental life as much as upon any purely objective conditions.

The group cannot be understood if the individual is ignored.

These various illustrations show the significance of an attitude toward social phenomena, in which the laws of mental organization and behavior are treated as the underlying structures upon which the descriptive and historical accounts shall be coördinated. Just as the zoölogical and biological explanations of animal life require a careful analysis of individual habits and of the structures of individuals in order to explain the

various types of adaptation, so the explanation of human society, considered as an interrelation of highly organized individuals, requires that there shall be a full account of the nature of the individuals which enter into the organization.

The relation of educational practices to scientific psychology.

Conspicuous among the social institutions to which psychology may be applied in a direct and practical fashion is the institution of education. Here again is a type of adaptation which has grown in an unscientific way to a high degree of maturity. This statement implies no disposition to deny the effectiveness of many of the practices of educational institutions. They may be effective without being scientific. They are the outgrowth of a need which has been felt by every generation, and the educational institutions which have been developed in response to this general need have been refined and modified in view of experience, until finally they express with a high degree of perfection the final judgment of many generations upon important questions connected with the training of the younger generation. Yet there are obvious reasons why these historical institutions should be reëxamined. Some of the natural institutions of education are found to be wasteful; again, the educational practices of different peoples or different sections of the same nation are found to be inharmonious. There arises, therefore, a demand for a careful analysis of the whole situation and the establishment of those practices which scientific analysis can justify. It is true that many hold the same attitude with regard to education that they do with regard to art; namely, that it is safer to rely upon the intuitions of human feeling than to attempt to formulate an abstract system of education. Those who adopt this position with regard to the advantages of intuition in education have justification for their position, in so far as educational practices are refined to a point beyond our knowledge of the laws of human development. The most acceptable plea for a scientific study of education which could be presented to such persons would consist in a plea for a more complete knowledge of the same sort which they have in

their native intuitions. It might be said, for example, that the study of educational methods involves nothing more than the bringing together of the individual experience and practice of all those who have become skilled in educational practice. A comparative study would help to eliminate those individual intuitions which are incorrect, because they are based upon too narrow experience.

Psychology as a preparation for the intelligent diagnosis of particular situations which arise in educational practice.

The final examination of educational practices must go much further, however, than implied in this appeal for a comparative study of intuitions. Attention must be called to the fact that much of our devotion to traditional educational practices is nothing more or less than a deliberate confession of our ignorance of the way in which the human mind develops. When a teacher is confronted by children who are unable to comprehend the lesson which has been set, he very commonly can make no analysis of the child's difficulty. He then covers up his ignorance of the step which should be taken to complete mental development by requiring repeated efforts on the child's part, until in some unknown fashion the difficulties are mastered. It does not follow that the particular difficulty encountered in any given case would have been recognizable if the teacher had made a study of human development in other individuals, but the probability that the trained teacher would be able to make a scientific analysis of the difficult situation at hand, would be increased if he were acquainted with the principles and results of scientific psychology. Intuition should, therefore, be supplemented by as full an account as can be given of the way in which mental processes go on and of the methods by which these processes may be examined.

Scientific principles of education in a formative stage.

One of the most vigorous branches of current psychology is that which makes a minute and careful study of all of those mental activities which appear in the developing individual. Many of the methods of such investigations are crude, and the results unformulated. There are many disputes among the workers in this field as to the particular conclusions which can be reached and as to the significance of their

individual positions on educational questions. The student who becomes acquainted with these differences of opinion should not be misled by the present lack of complete solutions and adopt a pessimistic attitude toward the applications of psychology to education. The fact is that criticism and counter-criticism with regard to an educational principle is simply an exhibition of the scientific spirit which will ultimately issue in the collection of sufficient evidence to make a clear and rational decision possible.

The complete study of habits.

A few illustrations may serve to make clear the place and value of the psychological study of educational problems. First, a number of investigations have recently been undertaken with a view to defining in detail the course of development of certain habits. Broadly stated, the conclusions of these studies show that no habit develops at all of its stages at a uniform rate. There is at the outset an improvement which is relatively very rapid; this is followed by a period of slow development, which in turn gives way to successive periods of rapid growth.

A curve illustrating the process of learning.

One of the earlest investigations of the way in which an individual learns may be described in detail. This investigation was undertaken to determine the rate at which a learner acquired the ability to send and receive telegraphic messages. The selection of this particular case for the test was due to the ease with which measurements of proficiency could be made, and to the maturity of the persons investigated, which made it easy to subject them to a series of tests. In Fig. 55 the results of the investigation are represented in a curve. Along the top of the figure are marked the successive weeks during which the investigation was carried on; along the vertical line at the left the number of letters which could be received or sent in a minute. A single point on the curve represents, accordingly, both a stage in the practice series and the number of letters which could be received or sent during a minute at this stage of development. The curves taken in their entirety represent the gradual increase in the ability of the subject. It will be noticed,

in the first place, that the improvement in sending and in receiving messages followed an entirely different law, both with reference to rate of improvement and also with reference to the successive stages of development. Concentrating attention for the moment upon the curve which records improvement in receiving, we see that

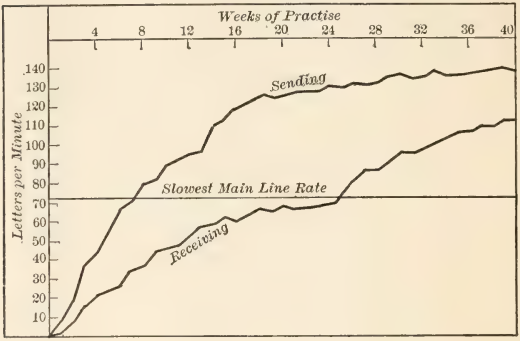

FIG. 55. Shows the curves for sending and receiving telegraphic messages. The curve is published by Bryan and Harter. The number of weeks of practice is indicated in the upper part of the figure. The number of letters which can be received and sent in a minute is represented in the vertical. For further discussion, *see* text.

the development is at first rapid and then for a long time practically stationary. After the stationary period, or plateau as the authors called this part of the figure, came a second rapid rise in the curve.

Significance of a "plateau" in development.

In Fig. 56 a second curve of the same sort is shown, which makes it possible to explain the pause or plateau in development. The lowest curve in this second diagram represents the development of proficiency in recognizing isolated letters. The second curve represents the development of proficiency in receiving isolated words which did not unite into sentences, and

the full curve represents, as before, the development of efficiency in receiving words which constituted sentences. It will be noticed that the ability to receive isolated letters and the ability to received isolated words developed rapidly for a time, until they reached their maxima, and then they continued indefinitely at the

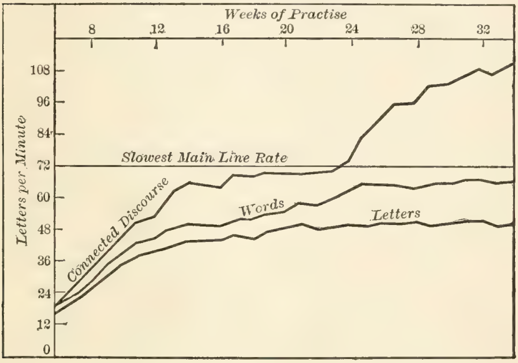

FIG. 56. This figure is similar to Fig. 55. For further discussion, *see* text.

same level. This level is so related to the plateau in the total curve that the plateau can safely be defined as the period during which the subject was in the word stage of development, rather than in the sentence stage. Only after the ability to receive single words had been thoroughly matured was a new type of development possible. The new type of development, as shown in the second rapid rise in the curve, was built upon material acquired before the plateau and assimilated during that stationary period.

Such an analysis as this of a habit of learning shows much with regard to the psychological character of the process. It also suggests the possibility of

The results of this experiment have many analogues in the general facts of organic development.

including the process of mental development under certain broad laws of development. There are many analogous cases in general evolution where it has been noted again and again that periods of rapid development are followed by long periods of assimilation. It is a well-known fact of bodily growth that the enlargement of the body is most marked at certain periods in the year and at certain well-defined periods in the child's life. After one of the sudden enlargements of the body, there follows a period of gradual assimilation of the new developments, during which the body remains stationary in its size for a considerable time. The facts of organic evolution on a larger scale are of the same type. During certain periods the animal kingdom has advanced rapidly by the production of new forms, after which long stationary periods appear, during which these new forms are more completely adjusted to their environment without being in any important sense modified. Such statements as these make clear the distinction between assimilation and acquisition in both the physical and mental worlds.

Other cases of periodic mental development.

The fact that certain forms of mental development are periodic rather than continuous is illustrated in many cases where quantitative tests have not been made. It has often been casually observed that a mature subject learns a foreign language, not with uniform rapidity, but in a way analogous to that shown in the curves given above. At first there is rapid acquisition of the words and grammatical constructions of the new language, but after a time the power to acquire new phases of the language seems to be brought to a standstill, and the period of discouragement which follows is often felt by the learner to be a period of no development, while in reality it is a period of assimilation and preparation for the later stages of growth. When the later development into the full use of the language comes, it is so sudden and striking in its character that it has been noted time and time again as a period of astonishing mental achievement.

Many habits of action exhibit the same type of intermittent development. If one learns some manual art, he finds that the incoördinations with which he begins are only gradually eliminated, but finally he learns the combination which is advantageous and from that point on the improvement seems for a time to be very rapid. It is sometimes advantageous in a course of training to give up practice for a time in order that the various elements of the coördination may have an opportunity to readjust themselves and in order that the new efforts at development may begin at a new level. Professor James has made the striking remark that we learn to skate during the summer and to swim during the winter. The significance of this observation is that it recognizes the intermittent character of the development of habit and the advantage of a period of assimilation, sometimes even of a period of complete cessation of the activity in question.

Motor habits intermittent.

From the point of view of practical education, it is obvious that the types of training which should be given at the different periods in mental development are by no means the same. During a period of rapid acquirement of new material, one sort of training is appropriate; during a period of delayed assimilation, that form of training is most appropriate which is technically known in the schools as drill. The ordinary unscientific education has recognized vaguely that there is a difference in the kinds of training demanded at different times, but the adjustment of these different types of training to the demands of individual mental development is an intricate problem which can be worked out fully and satisfactorily only when a careful study is made of the individual development as well as of the general requirements of educational practice.

Training should fit itself to the stage of development attained by the mind.

The value of scientific studies of habits and of forms of training is shown by such considerations as the foregoing. It also becomes evident that such studies do not necessarily change the subjects of instruction nor even the general methods established

The significance of scientific studies may be direct or indirect.

by tradition, but serve rather to refine our knowledge of the process of mental growth and make it possible for us to deal with different stages of the educational process with much greater precision. To justify scientific investigations which seem at first sight remote from school problems, it may be well to point out that the solution of one problem in mental development makes it possible to attack all other problems of a similar kind more intelligently. If one knows with scientific precision that a period of assimilation occurs in one case of mental development, he will be better prepared to discover and understand a similar period in other cases where it may be less easy to make an exact scientific study. For example, we can understand, in the light of the telegraphic study, the nature of the transition which comes in the child's life when he passes from the reading of single words to the reading of full sentences. The mastery of the word elements in ordinary reading is similar to the mastery of these same elements in the case of the telegrapher.

Expression as an essential condition of mental life.

Another concrete illustration of educational progress may be found in the fact that there is a general disposition among educators to-day to recognize the importance and value of expressive activities in all educational processes. The early type of education was that in which sensation processes were emphasized almost to the exclusion of activities. Whether the educational practice which emphasized impressions can be attributed to the sensation psychology which was contemporary with it, or whether the sensation psychology was the outgrowth of a false educational theory, is a question which need not be discussed here. Certain it is that the limited view of mental life and the false principle of education, both of which emphasized impressions rather than expression, existed for a long period side by side. It may have been the growing experience of practical teachers which led to the discovery of the fallacy in the doctrine that mind is conditioned primarily by impressions. It may have been the insight of scientific

students which gradually made it clear that human activity must always be recognized in discussing the processes of mental development; or it may be that the two lines of thought and practice grew up together. In any case, it is certain that a transformation of educational practice and a corresponding transformation of psychology have been going on for a generation, until now we have scientific principles and educational practices which look toward the emphasis of expressive organizations.

Psychology historically a part of philosophy.

Turning from these practical applications of psychology to education, it remains for us to discuss one of the applications of psychology which has always been recognized in the historical development of this science; namely, the relation of psychology to the philosophical disciplines. Indeed, it may be said that psychology was not only applied to the problems of philosophy; it was originally devoted to the discussion of these problems to such an extent that it was regarded as an integral part of philosophy, not as an independent science. Philosophy deals with the ultimate nature of matter and mind, with the fundamental laws of reality and the relation of reality to human experience, with the ultimate nature of truth, goodness, and beauty. There have been times, for example, during the mediæval period, when the interest in such ultimate problems ran so high that there was little or no attention given to the special problems of science. The time came, however, with the development of modern thought when these larger problems receded into the background and men began to concern themselves with the phenomena in the world rather than with the ultimate realities underlying these phenomena. It is characteristic of the present scientific period that the special sciences neglect to as great an extent as possible the questions of ultimate reality. The student of psychology participates to a very large extent in this tendency to omit from his discussion questions relating to the ultimate nature of mind. He cannot, however, accept as final this aloofness from the

broader questions, for he finds himself, more than his neighbor who deals exclusively with the natural sciences, led to ultimate problems.

Relation of psychology to philosophy closer than that of any of the special sciences.

When, for example, one points out that a sensation is related to a fact of external energy indirectly through the organs of sense, or when one points out that space is a definite form of perception on the one hand, and of arrangement of objects on the other, the psychologist is driven to consider the relation between consciousness and the external world more than the student of the other particular sciences. The student of natural science uses in every act of observation the relation between subjective experience and the physical world; he exercises his mind in trying to know the world, but his interests are always centered on the relations between things, never on the relation between things and consciousness. Hence the student of natural science easily avoids questions relating to the ultimate interaction between himself and the physical world. The student of psychology cannot escape these questions. His study of sensation grows out of the examination of this relation. Furthermore, when the student of psychology finds that the construction of concepts is an elaborate mental activity which depends upon certain forms of active organization of contents derived through perception, he is immediately led to ask, not only what are the laws which control such conceptual activity, but also what are the relations of mental activity to external reality, and what are the laws which determine the validity or lack of validity of these concepts. It is true that psychology cannot answer all of these questions, and it has been our purpose in the foregoing discussions to adhere as closely as possible to the sphere of strict psychological inquiry, postponing these ultimate questions or entirely omitting them. It is, therefore, very appropriate that we should call attention at the end of our inquiry to the disciplines which deal with these more elaborate inquiries, and that we should define the relation of psychology as introductory to these broader disciplines.

One of the branches of philosophical inquiry most closely related to psychology is logic. Logic deals, as was pointed out in the chapter on the formation of concepts, with the different forms of thought and the laws of their validity. The discussions of thought processes must always include some account of the nature of these processes. The complete description of logical processes depends upon the development of psychology. This statement can be verified by reference to the history of logic. Aristotle indeed defined with great precision the fundamental principles of deductive reasoning, as he found them exhibited in the modes of thought of the best thinkers of his time. We have never, on the other hand, succeeded in getting a full and satisfactory account of the processes of reasoning employed in modern science, because these processes are immensely more intricate than those which Aristotle selected and discussed in his treatment of deduction. The complexities of modern reasoning will never be fully accounted for until a complete psychological analysis is carried out. The psychological analysis is not absolutely necessary for intelligent criticism of the validity of reasoning processes, for reasoning may be tested by its consequences. Many systems of logic have been worked out by thus testing the various possible combinations of thought, neglecting entirely the analysis of the mental processes involved. Such practical systems of logic should, however, be supplemented by explanatory psychological treatments of thought processes. Our treatment of concepts and judgment shows the direction in which study is to be directed if we are to attain a complete logic based upon the thorough scientific explanation of mental processes.

Psychology and logic.

The same line of discussion may be followed in describing the relation between psychology and æsthetics. In earlier chapters reference has been made repeatedly to the underlying principles which control the recognition of symmetry and regularity of form, and it was there pointed out that the canons of architecture and painting are directly related to certain fundamental principles of human feeling

Psychology and æsthetics.

and recognition. There still remain a large number of special analyses and special considerations which must be worked out in order to define fully the canons of taste in each field of art and the general canons of taste which underlie all forms of art. Such considerations of the canons of art constitute a legitimate development of the general psychological studies which have been suggested, and constitute the special discipline of æsthetics.

Psychology and ethics.

When we turn to the third of the special philosophical disciplines, namely, ethics, we find again a natural relation to psychology, though it is perhaps proper to emphasize here more than in the case of logic or æsthetics the independence of ethical canons from purely subjective organizations. The rightness or wrongness of human behavior is not understood primarily through an analysis of the processes of behavior themselves. The rightness or wrongness of behavior depends upon certain broad considerations involving the social interrelationships of the active individual. It is necessary, therefore, to make a study of the extra-mental or social relations of the individual in order to establish the canons of ethical conduct. One does not need to discuss the extra-mental relations to anything like the same extent when he attempts to define the laws of reasoning in logic or the laws of appreciation in æsthetics. It is true that the individual's modes of behavior, as they have been worked out in the course of social life, come to embody much of the social interrelationship which determines their ethical validity. The individual who has grown up in a social group ultimately conforms in his modes of thought and internal organization to those social demands which are imposed upon him by the community in which he lives. It is probably true, therefore, that in the last analysis the fundamental truths of ethics are expressed in the internal organization of the individual as well as in the forms which are approved under the canons of social life, but the development of ethical laws lies somewhat beyond the application of psychology. We come to ethics chiefly

through the study of the applications of psychology to the sciences of social institutions.

Psychology and metaphysics.

When we turn from the special philosophical disciplines to the broader field of metaphysics, or the general theory of reality, we find again that the relation of psychology to these broader types of consideration is relatively indirect. Metaphysics takes up the results of natural science which deals with matter and of psychological science which deals with consciousness, and attempts to formulate some general principles of the relations between all forms of reality. To this general discussion psychology cannot contribute final answers any more than could the special sciences of physics or chemistry. Psychology can only present its conclusions after it has carried out as complete an analysis of consciousness as possible, and must leave it for metaphysics to make an ultimate comparison of these facts with the physical facts. The student who finds that an empirical analysis of consciousness conflicts with any of the established views which constitute a part of his general theory of the world, should recognize that it is not the function of any single science to reconstruct his total theory of the world. He will have to accept the results of empirical analysis in all the different spheres of exact research and work out a general view which will include all of these results. The conclusions of psychology need to be generalized exactly as do the conclusions of physics and chemistry. No generalization will be finally valid which does not comprehend the empirical analysis of each one of these sciences. Furthermore, it should not be forgotten that there are many types of consideration which forced themselves upon human attention long before the various forms of scientific analysis could be worked out, and these considerations must also be recognized in the construction of a broad philosophy of life. That the generalizations which were reached before the development of the special sciences, should require revision in order to include the results of these sciences, need not disturb the mind of any student, and need

not lead him to ignore many non-scientific types of experience. The training in scientific inference which he has received in the study of empirical psychology should lead him to recognize that all generalizations are subjective constructs built up from a great variety of experiences, many of which are superficially in disagreement with each other. The subjective construct is not to be discarded as invalid, because it changes with the acquisition of new knowledge; one's theory of the world must change in order to fulfill its function as a complete, organized expression of the manifold experiences which enter into life. Psychology, more than any other science, should lead to a recognition of this demand for a constantly progressing enlargement of philosophic view. While, therefore, modern psychology as a science has freed itself from the obligation of dealing with the broad philosophical questions, it continues, when rightly understood, not only to contribute material for philosophic thought, but also to urge the student to the rational reconstruction of his general abstract views. It is, therefore, introductory, not merely to the special philosophical disciplines, but also to the more remote discussions of metaphysics itself.

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